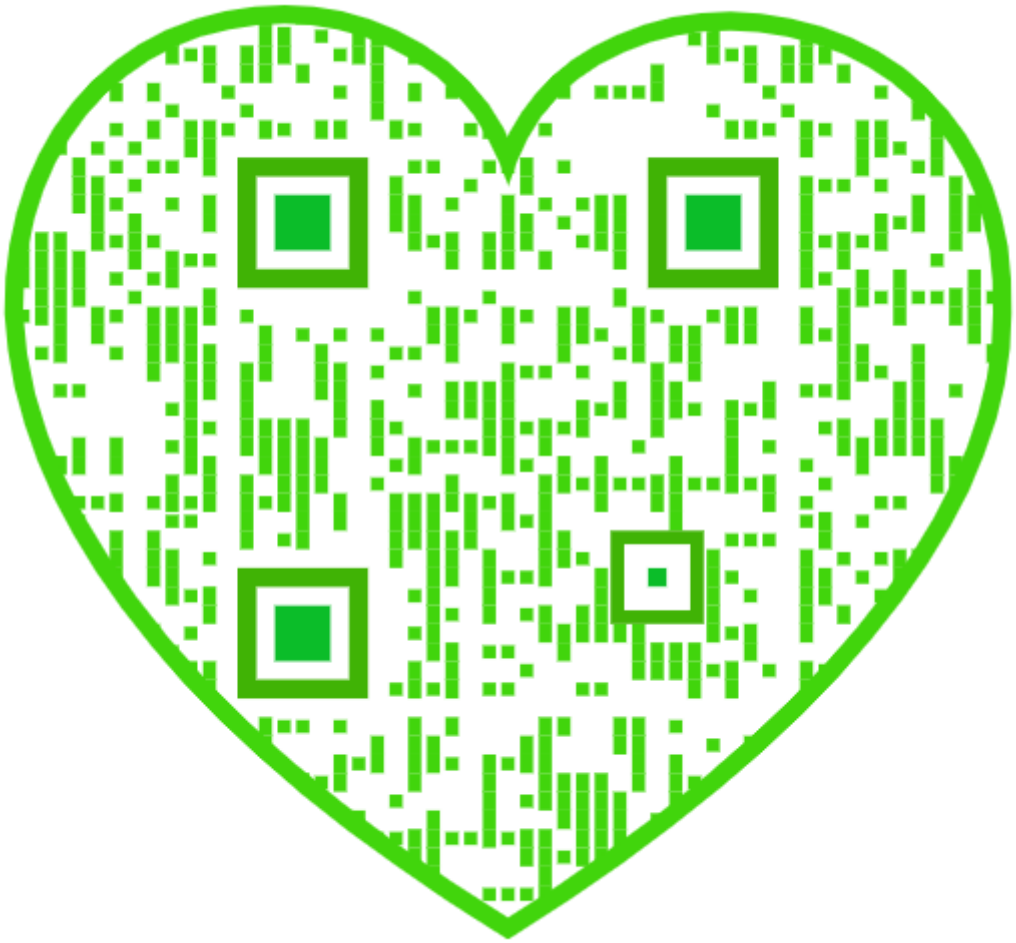

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CARPENTRY

By

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ACKNOWLEDGMENTS

To my father, whose patient instruction and forbearing oversight during the period of carpentry apprenticeship has made possible the practical aspect of this present volume, grateful acknowledgment is made.

Acknowledgment is also made of assistance derived from the various trade magazines and from the few books on carpentry.

Credit is due Mr. Franklin G. Elwood, Peoria, for most of the excellent drawings which accompany and clarify the text. A number of the drawings were penciled by Gordon Kellar, Boston. The photographs are the work of James F. Barham, Columbia, Mo.

I. S. G.

PREFACE

IT is the author's hope that the following text may be of service to apprentices to the trade, to vocational and trade school students, and to manual training students. The author's experience as a carpenter leads him to feel that not a few journeyman carpenters may find their horizon widened and their usefulness as framers of the unusual roof increased by a study of Chapter IV where an effort has been made to indicate how the principles involved in framing the square and octagonal roof may be "generalized" so as to make possible their application to roofs of any number of sides. Beyond this, the book makes claims to being nothing more than an elementary treatise of the essentials of carpentry.

No apology is offered for making use of trigonometric solutions of plane right triangles as a basis for developing generalized roof framing principles in Chapter IV. There is absolutely nothing in the use of natural trigonometric functions to prevent their introduction early in the mathematical experience of a boy, except academic tradition. The author has made use of this mathematical tool with upper grammar grade boys with less effort upon their part in mastering the principles than was expended in mastering square root. The ease with which roof framing problems lend themselves to solution by the use of natural trigonometric functions and the readiness with which problems may be generalized thereby has emboldened the author to make use of it in a text as elementary as this. No previous knowledge of trigonometry is presupposed, the Appendix provides all the information required for the solution of any problem given herein.

Should a reader, because of lack of time or for any other cause, not care to consider more than roof framing of the square cornered building, he will find a complete treatise in Chapter III without reference to solutions other than by common arithmetic. Appendix IV offers a still more abbreviated approach to both square and octagonal roof framing.

The greatest good in studying the chapter on "Estimating" will come only when each student is provided with a set of plans and specifications completely drawn, as by a practicing architect. Plans and specifications, such as will serve the purpose, can be purchased at small cost from architectural companies, should local architects be unwilling to provide sets for the schools.

Also, there must be provided for each student, catalogs of lumber and millwork specifications and prices. These can be obtained from mail order lumber and millwork companies. As a rule, local lumber and millwork companies are glad to provide such data, but it must be in a form complete, and readily accessible to be of the greatest value.

IRA S. GRIFFITH.

COLUMBIA, MISSOURI,
September, 1916.

CONTENTS

CHAPTER I. FOUNDATIONS 13

1. Laying out; 2. Grade line; 3. Excavation; 4. Foundations; footings; 5. Foundation materials; 6. Forms for concrete walls; 7. Waterproofing; 8. Basement frames.

CHAPTER II. MAIN FRAME . 27

9. Methods of framing superstructure; 10. Sills and girders; 11. Bridging; 12. Trimmers and headers; 13. Walls and partitions; joists and rough floors; 14. Openings in framework.

CHAPTER III. ROOF FRAME: SQUARE CORNERED BUILDING 45

15. Roof framing; 16. Framing the common rafter; laying out the plumb cut; 17. Finding the length of a common rafter; 18. Laying off a common rafter seat cut and end cut. 19. Ridge piece; 20. Hip and valley rafter; 21. Framing hip and valley rafters; 22. Side or cheek cut of hip or valley rafter; 23. Determining length of hip or valley rafter; 24. Laying off seat cut and end cut of hip rafter; 25. Reduction of hip or valley length because of ridge piece; 26. Backing a hip rafter; 27. Valley rafters; 28. Framing jack rafters; plumb cut; side cut; 29. Lengths of jacks..

CHAPTER IV. ROOF FRAME: ANY POLYGON . . . 69

30. Tangents; miter cuts of plate; 31. Octagonal roofs; 32. Common rafter for plate of any number of sides; 33. Hip and valley rafters for octagon and other polygons; 34. Plumb cut of octagonal and other polygonal hips and valleys; 35. Side or cheek cuts of hip or valley rafters, any polygon; 36. Rafter lengths of octagonal and other polygonal hips and valleys; 37. Reductions in lengths for king-post; 38. Seat cut and end cut of octagonal and other polygonal hips and valleys; 39. Backing octagonal and other hips; 40. Framing octagonal and other polygonal jacks; 41. Side cut of octagonal and other polygonal jacks; 42. Lengths of octagonal and other polygonal jacks;

43. Framing by means of a protractor; 44. Translating framing problems from protractor to framing square and vice versa; 45. Framing an octagon bay; 46. Framing a roof of one pitch to another of different pitch; 47. Framing roof of uneven pitch; 48. Decks; chimney openings.

CHAPTER V. EXTERIOR COVERING AND FINISH . 95

49. Sheathing; 50. Scaffolding; 51. Cornice; 52. Raked mouldings; 53. Shingling; 54. Shingling hips and valleys; 55. Finishing exterior walls; 56. Setting window and door frames; 57. Siding.

CHAPTER VI. INTERIOR FINISH 115

58. Lathing; grounds; 59. Interior walls; 60. Stair building; porch steps; 61. Risers and treads; 62. Porches; 63. Interior finish; 64. Setting door jambs; 65. Fitting window sash; 66. Placing door, window, and other trim; 67. Hanging doors; 68. Fitting a door; 69. Hinging a door; 70. Fitting locks; 71. Laying and scraping floors; 72. Door and window frames; 73. Woodwork in masonry structures.

CHAPTER VII. ESTIMATING 142

74. Methods of estimating; 75. Table for estimating by cubic-foot unit; 76. Grading rules; 77. Estimating lumber quantities; 78. Estimating millwork quantities; 79. Example of form for bill of materials; 80. Estimating labor costs; 81. Estimating quantities of nails; 82. Example of form for carpentry costs; 83. Total building costs by percentages.

APPENDIX 158

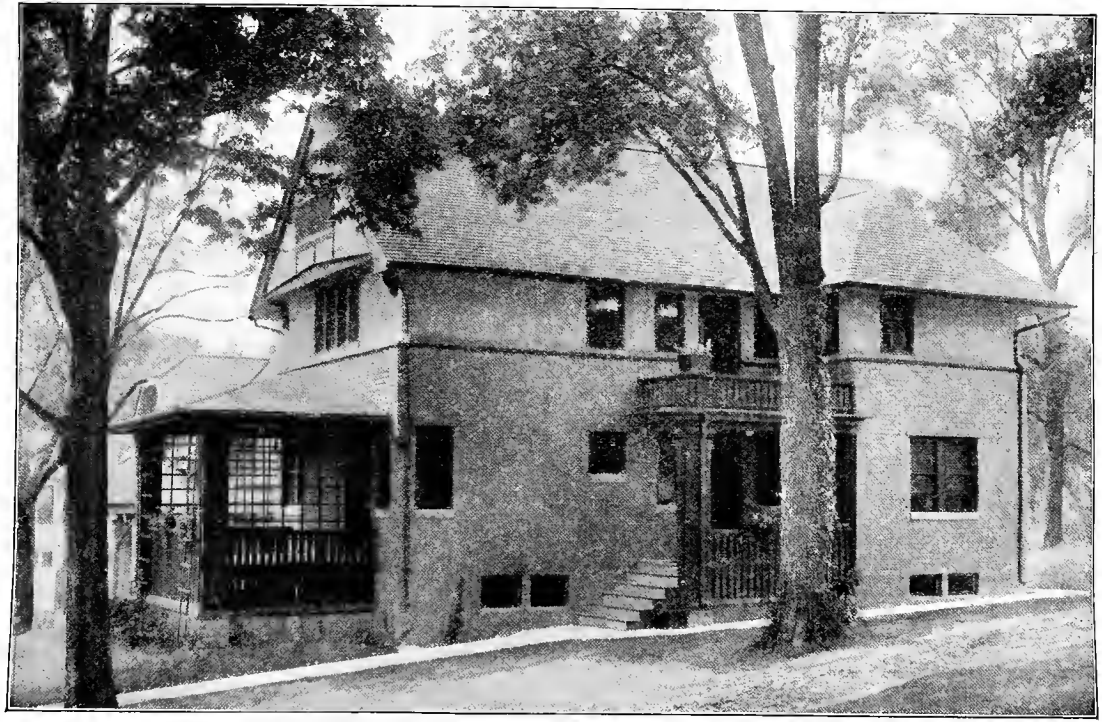
I. Natural trigonometric functions; formulæ deduced. Solution of right triangles. (brief)

II. Table of natural functions (for degrees only). Interpolation.

III. Useful tables.

Fractional equivalents for decimal values.
Wood and machine screw sizes.
Length and number of nails.
Wire brads.
Board measure table.
Strength of materials.
Stresses for structural timbers.
Contents of brick walls.

IV. Short cuts to roof framing.
Directions for Griffith's Framing Tables.
V. Estimating.
Excavations.
Masonry.
Slate.
Plaster.
Painting.
Bibliography of References.



The house used as a model for many of the illustrations in this book

CARPENTRY

CHAPTER I

FOUNDATIONS

1. Laying out Foundations. — In most communities it is customary for the carpenter to be present and to assist the mason in the laying out of the foundations. Where buildings are large and important, this work is done by an engineer with a steel tape and a surveyor's instrument, Fig. 1. This instrument is known as a builder's transit, and consists of a tripod upon which rests a small telescope with crossed hair wires within, by means of which the observer may fix the line of sight very accurately. A circular dial contains a magnetic needle which enables the fixed dial to be set with reference to the true north and south line of the observer. After the fixed dial has been adjusted, the telescope may be swung to the right or the left until the circular graduations indicate that it points in the direction wanted, after which stakes may be set.

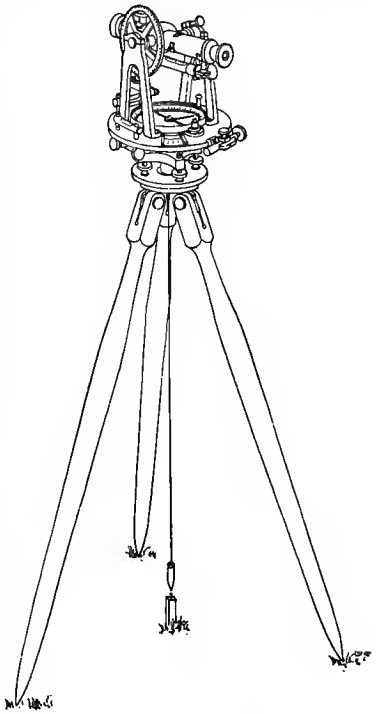


Fig. 1. Transit

A level upon the telescope enables the observer to sight grades or levels; a helper carrying the leveling rod, Fig. 2.

Fig. 3 shows a more common instrument. This is an architect's Y-level and differs from the other in that it is less complete. It has no attachment for measuring vertical angles. This is not serious, however, since the builder seldom needs such an attachment, the level being the most essential part. Y-levels are made both with and without compass attachments.

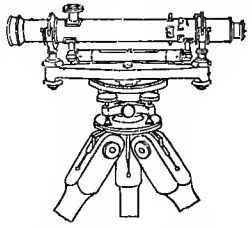


Fig. 3. Y-Level

Upon ordinary residence work a surveyor is employed to locate lot lines. Once these lines are located the builder is able to locate the building lines by measurement. Suppose it is desired to locate a building by means of the side lot line: (1) Measure from the side lot line, along the front and along the back lot lines, a distance equal to that which it is desired the house shall hold relative to the lot side line. Drive stakes here. (2) While sighting from one of these stakes to the other, have an assistant locate two other stakes in the line of sight, a distance apart sufficient to guarantee the placing of the cross-lines for the back and front of the house without restaking these, *A–B*, Fig. 4. The process of laying out lines for a house is almost identical with that used in laying out a rectangle on a drawing board. (3) Having located a line of indefinite length for one side of the house, a second line of indefinite length, preferably for the front of the building, may next be located. To do this, first locate a front corner stake upon the first line just located. This is done by measurement from the

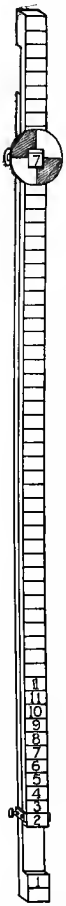


Fig. 2 Leveling Rod

street line. Having located and driven in this stake, *A*, Fig. 4, drive a nail in the top of the stake to more accurately locate this corner. If an instrument is available it will be located over this stake and the front line *A–C*, Fig. 4, located by laying it off at 90 degrees from the side line already located. If no instrument is available, the front line may be laid off at right angles to *A–B* by holding a framing square at their intersection. This angle should be verified by the 6–8–10 method. This consists in measuring from the

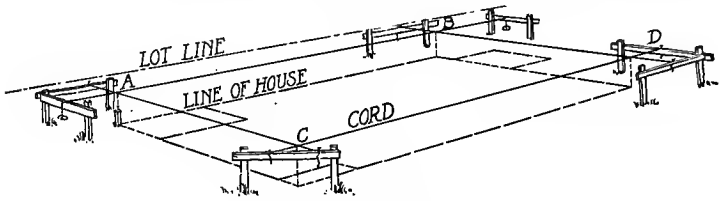


Fig. 4. Batter Boards

intersection at *A* along one line a distance of 6 feet and sticking a pin in the line at that point; a pencil mark may be used when the cord is white. In a similar manner, measure off 8 feet along the other line and then measure the hypothenuse of the triangle so formed. It should measure 10 feet. If it does not, the front building line must be shifted until it does. (4) With these two lines located, the remaining two lines may be located by measurement from them, the nail of stake *A* giving the starting point. Before this is attempted, however, the batter boards should be placed. Batter boards are variously constructed. Those shown are common types. They should be placed free of the foundation proposed by at least 3 or 4 feet. (5) Test the squareness of the whole lay-out by measuring the diagonals *A–D* and *B–C*. If the building lay-out is square the diagonals should be equal. If they are not equal, shift the cords at *C* and *D*, retaining their parallelism, until the diagonals become equal. (6) Once the lay-out is correct,

saw kerfs should be made in the batter boards where the cords are placed. These kerfs will permit the cords being removed and replaced without further measuring.

2. Grade Line.— A properly drawn set of plans will show both the present lay of the ground upon which the building is to be erected and the new grade line which is to be established after

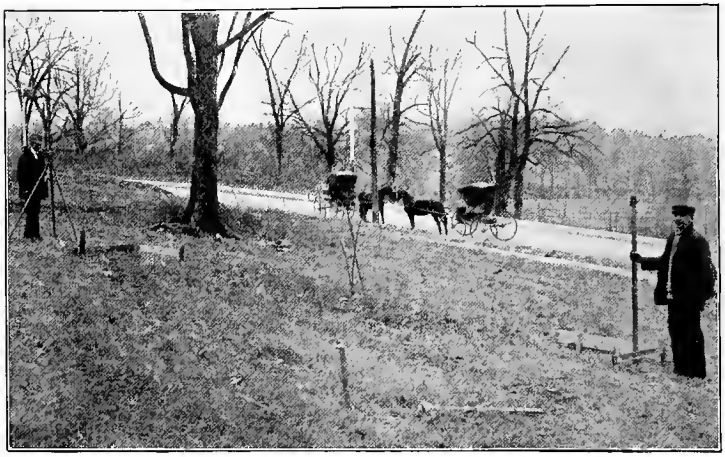


Fig. 5. Taking Sights with Y-Level

the building is completed. The most convenient method of determining old grade lines and of establishing new ones is by means of the transit, Fig. 1, or the Y-level, Figs. 3 and 5, with the rod, Fig. 2. Both instruments operate upon the same principle in grade work. The telescope is set level and sights taken thru it to the target upon the rod. The reading of the target's position upon the rod compared with the height of the telescope above the base, usually the street walk, determines the difference in grade of that particular placing of the target.

To locate levels for the masonry, (1) set the instrument at some

convenient place and level the dial. (2) Having determined the height of the instrument above some predetermined base, such as the street walk, swing the telescope about and, making allowance for the difference in level as shown by the drawings, place successively stakes at each corner of the building with the required level marked thereon. As a rule, the mason has his own Y-level and uses it freely as the wall is constructed, especially where levels are to be maintained as the layers of material are placed.

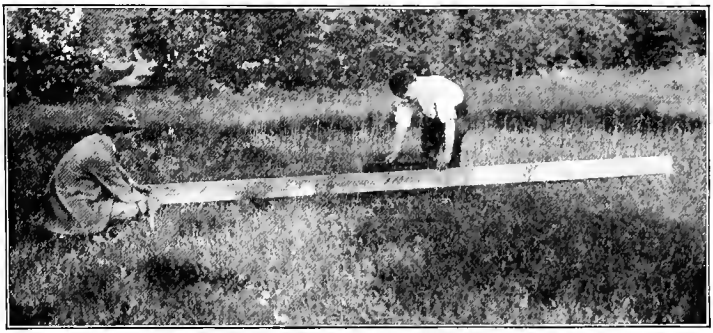


Fig. 6. Leveling with Straight-edge

In a similar manner the earth grade about the building may be located, stakes being driven into the ground at frequent intervals and the amount of " fill " or reduction indicated thereon. Grade levels are established usually only after the builders are thru, except that the mason will have the grade indicated for him where the wall above the grade is to be differently finished from that below.

Where no surveyor's level is at hand, the mason or carpenter will secure the levels by means of a straight-edge of some 14 feet in length. A common level is placed upon this plank as shown in Fig. 6. By successive levels with stakes driven to indicate the

successive levelings, a grade may be carried quite a distance without very great variations.

3. Excavations. — Excavations should be made enough larger than the proposed foundation that the mason may have room to wield his trowel in pointing the outer joints, and for waterproofing. An extra foot of excavation upon each side will usually be required.

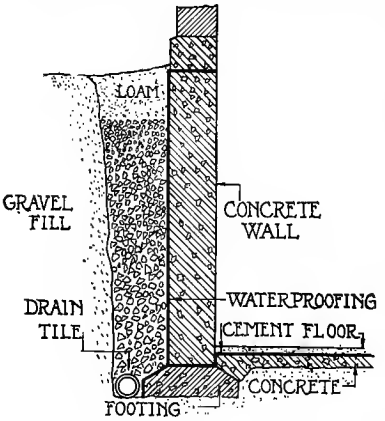


Fig. 7. Foundation Detail

All foundations must be carried well below the frost line. Excavations should be made accordingly.

4. Foundations; Footings. — Because of the tendency of a building to settle unevenly, due to variations in the strength of the supporting ground or the unequal weight placed upon this ground, foundations must be constructed of some non-yielding material such as brick or stone, and of such thickness and so bonded that the weight of the building may be evenly distributed.

The thickness of wall will depend upon the weight to be supported and upon the character of the soil.

Unless rock or gravel is encountered, every foundation should have a footing, Fig. 7. The amount of footing used is usually twice the thickness of the foundation wall. In brick walls this footing draws into the wall by "stepped" courses of brick, each layer being narrower than the one just preceding. For ordinary residence work with ordinary soil conditions a 10- or 12-inch wall resting upon a footing 2 feet wide and 8 or 10 inches deep will suffice.

A safe footing for supporting posts of 6″ x 6″ yellow pine, for most soils, will be 10 inches deep by 18 inches square. Partition walls carrying no unusual load need not be over 8 inches in thickness.

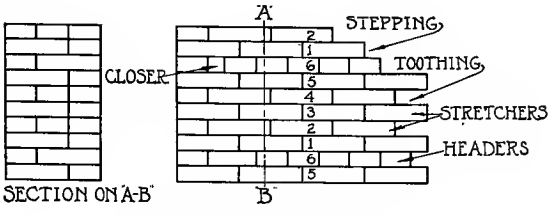


Fig. 8. American Bond

In many communities the use of concrete is supplanting that of stone or brick, especially below the grade line. Such a wall should be composed of 5 parts of crushed stone or gravel, 3 parts sand, and 1 part cement. The footing may be formed by tamping

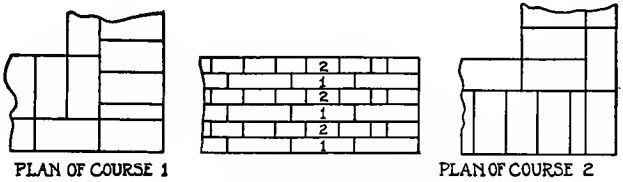


Fig. 9. English Bond

the mixture in a form made by spading out of the earth a depth and width sufficient for the wall to be supported.

5. Foundation Materials; Construction.— Of the materials commonly used in the construction of foundations monolithic concrete is becoming the most common for that part of the wall which lies below the ground or grade level. Brick and stone are sometimes used.

Where brick or stone is made use of, some device is required to "tie" the material together, due to the fact that the mortar used

in filling the voids or spaces between the members has little strength as compared with that of the stone or brick itself. This bonding is secured by placing the brick or stone so that they shall overlap one another, both along the faces of the wall and across the wall.

Bricks laid with their lengths in the same direction as that of the wall are known as stretchers; those laid with their lengths across the wall are known as headers, Fig. 8. The manner of

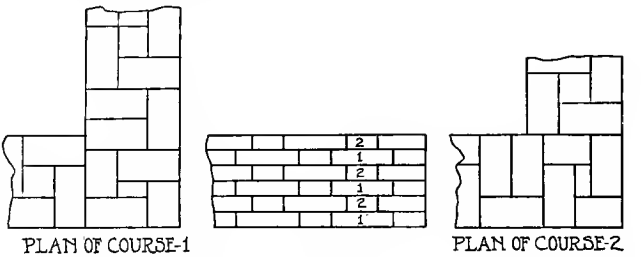
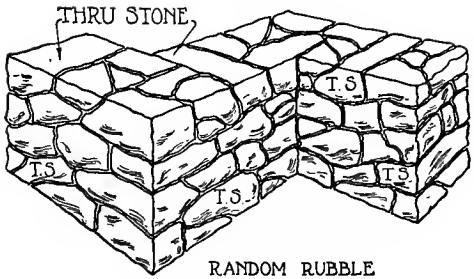


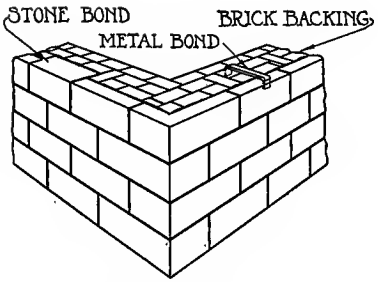
Fig. 10. Flemish Bond

placing these headers among the stretchers determines the type of bond. The American, English and Flemish are the more common types. Of these the American, Fig. 8, is the most used upon ordinary work. It consists of a course of headers placed every sixth course. The English bond, Fig. 9, is much stronger, having every other course a header course. It is used mainly upon very important work where unusual strength is required. Flemish bond is illustrated in Fig. 10.

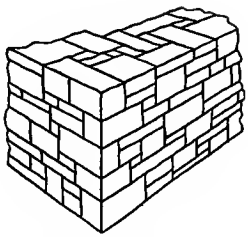
Of the various types of stone work, rubble work and ashlar predominate, Fig. 11. Rubble work is most frequently used for that part of the wall below the grade line, and ashlar for the remainder of the wall. In either case, thru stones are placed every 4 or 5 feet in the length of the wall and every 18 inches in the height, to provide bonds.



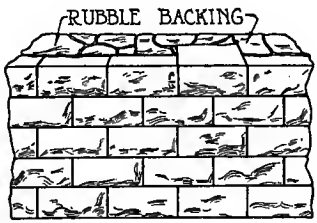
RANDOM RUBBLE



COURSED ASHLAR FACING



BROKEN ASHLAR



ROCKFACED ASHLAR

Fig. 11. Types of Stone Work

In rubble work the stones are rough and unhewn. They must be laid upon a good bed of stiff mortar with their stratifications in a horizontal position. Otherwise, the face of the wall might "peel" from the effects of frost and moisture, making an unsightly as well as a weaker wall. The term "ashlar" refers to a wall

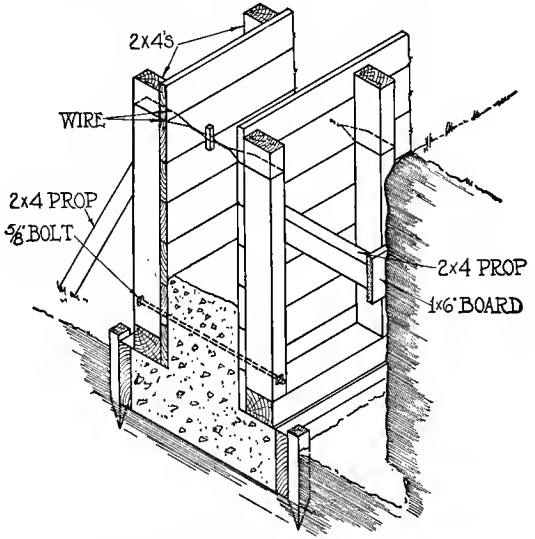


Fig. 12. "Form" for Concrete

builded of stones having finished faces. When either rubble work or ashlar is laid up in courses it is known as coursed rubble or coursed ashlar. When the horizontal joints are not continuous the wall is known as random rubble or broken ashlar.

Not infrequently a wall will be constructed with an ashlar facing attached to a brick backing by means of metal bonds. In such a wall, the faced ashlar, unless more than 8 inches in thickness and well bonded into the wall, should not be considered in estimating the strength of the wall.

In the construction of both brick and stone walls the work

should be carried up as nearly as possible at the same levels. In both brick and stone walls the corners are run up with stepped courses, the corners being plumbed as the wall is carried upward. A line is then stretched between the corners and, layer by layer, the rest of the wall filled in. No corner should, ordinarily, be carried more than 3 feet above the rest of the wall. In the case of uncoursed stone work the wall is leveled every 15 to 18 inches in its height.

6. Forms for Concrete Walls.— The economical building of forms for concrete walls is a matter of importance in building construction. Fig. 12 shows a type of form suitable for foundation work. Such forms should be made of semi-seasoned stock. Thoroly seasoned stock will warp badly when the wet concrete is placed. Spruce, Norway pine, etc., are better woods to use than hard or Georgia pine.

For ordinary foundation work 1-inch boards may be used, the studs being placed not over 2 feet apart. These studs may be assisted materially in holding the forms in position, by wires placed as in Fig. 12, and by props placed against the dirt wall of the excavation.

In placing the concrete a 4-inch layer is laid and then "spaded" or "worked" well into place, a "wet mix" being used. The smoothness of the resulting faces is increased by an additional spading of the mixture away from the form. A good spading tool is made by straightening out an ordinary garden hoe. This allows the cement and mortar to flow next to the form and hold this place while the filling proceeds.

Where forms are placed to give finished walls, that is, walls to which no plaster is to be applied, they should be aligned with no greater variation than $\frac{3}{8}''$ from the lines specified.

Forms should be allowed to remain until the concrete will resist indentation with the thumb, upon ordinary walls.

There is no limit to the ingenuity one may make use of in form building. The illustration given is merely suggestive.

7. Waterproofing.—The extent to which a wall should be waterproofed will depend upon the location of the building. Foundations near running water must naturally be better protected

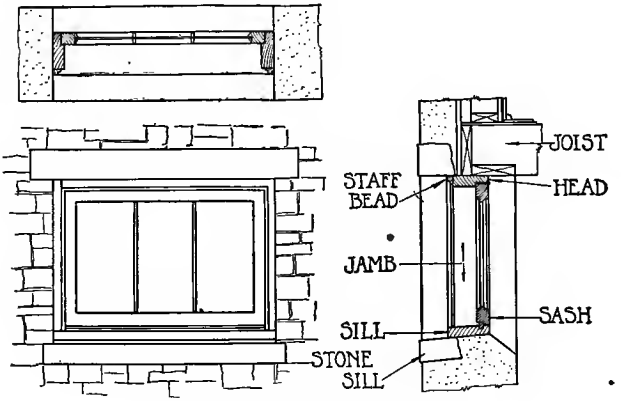


Fig. 13. Cellar Frame with Sash

than those in well drained locations. Fig. 7 illustrates a treatment which will prove quite safe for almost all localities. The exterior face of the wall is covered with several layers of asphaltum or tar. By coating the top of the footing and the top of the concrete floor just before the finish floor of cement is placed, little water will enter. A drain tile carried about the house as shown in Fig. 7, especially if gravel is placed against the wall above it, will meet every emergency.

There are other ways of waterproofing basement walls, but this is typical of the external wall treatments. In monolithic construction waterproofing may be secured by appropriate additions to the mixture of waterproofing materials such as slacked lime, just before the mixture is placed, no external applications being required.

8. Basement Frames.— Fig. 13 illustrates one successful form of basement window frame construction, with sash. In this type the sash is hinged to the top of the frame, and a catch or button at the bottom of the frame secures the sash when closed. The

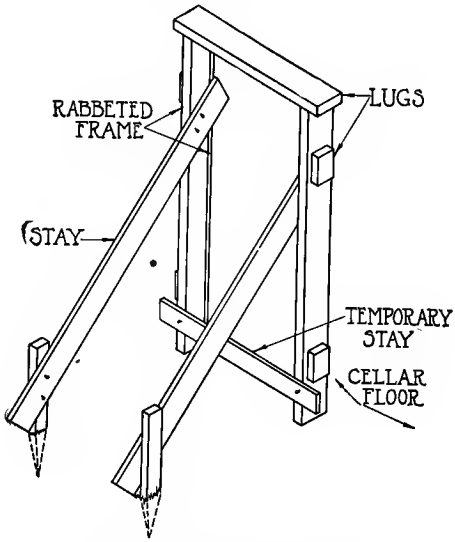


Fig. 14. Basement Door Frame

construction is such as to best shut out wind and water when the sash is closed.

Fig. 14 illustrates a basement door frame. Frames such as this, and the window frame of Fig. 13, are made of heavy stock and are known as plank frames.

Basement frames are held in place by means of wooden blocks nailed to the sides of the frame, as well as by the projecting "lugs" of the frame itself. The frame is set and plumbed by the carpenter as soon as the mason has prepared the sill. Fig. 14 shows a frame plumbed and stayed, ready for the mason to lay the adjacent

wall. Fig. 15 indicates the position of plumb and level in the setting of a frame. The edges of a door frame are "sighted" for wind.

Where it is necessary to attach frames or other woodwork to brick walls, it is customary to have the mason insert wooden

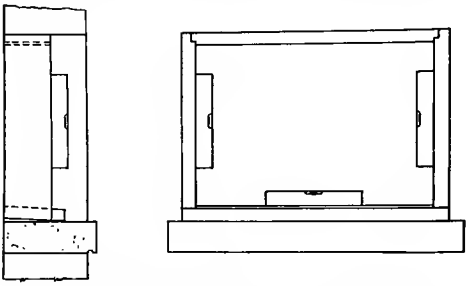


Fig. 15. Plumbing and Leveling Cellar Frame

"bricks" as the wall is constructed. Wooden bricks are of the same size as other bricks, and should be constructed with the edge which is to be laid back in the wall thicker than the front edge, so that a dovetailed effect is secured.

CHAPTER II

Main Frame

9. Methods of Framing the Superstructure.— In the early days when lumber was plentiful, houses and barns were framed in what is known as "full frame." Such frames consisted of heavy and solid timbers mortised and tenoned and pinned together, Figs. 16 and 17. With the growing scarcity of lumber the "half frame" of Fig. 18 became common. This latter type, it will be seen, makes less use of heavy timbers and wooden pins, and more use of planks and nails. To-day the vast majority of buildings, where wood is the material used, are constructed by what is known as "balloon framing" in houses and "plank framing" in barns, Figs. 19 and 20. In view of this, attention will be directed

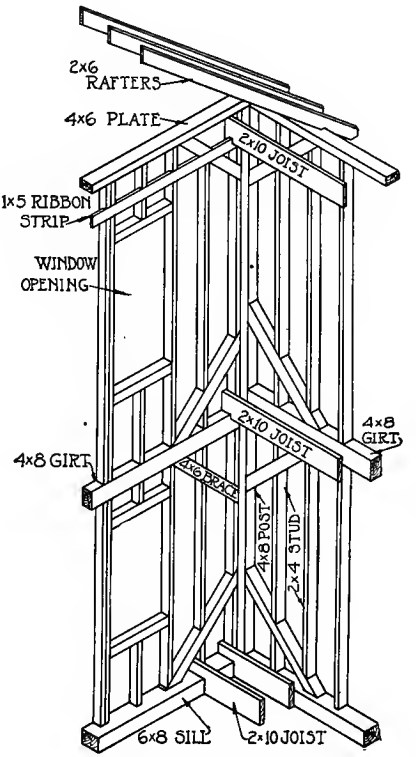


Fig. 16. Full Frame House

to balloon framing only. One who is able to frame a house should have no trouble with plank barn framing, where drawings show the details.

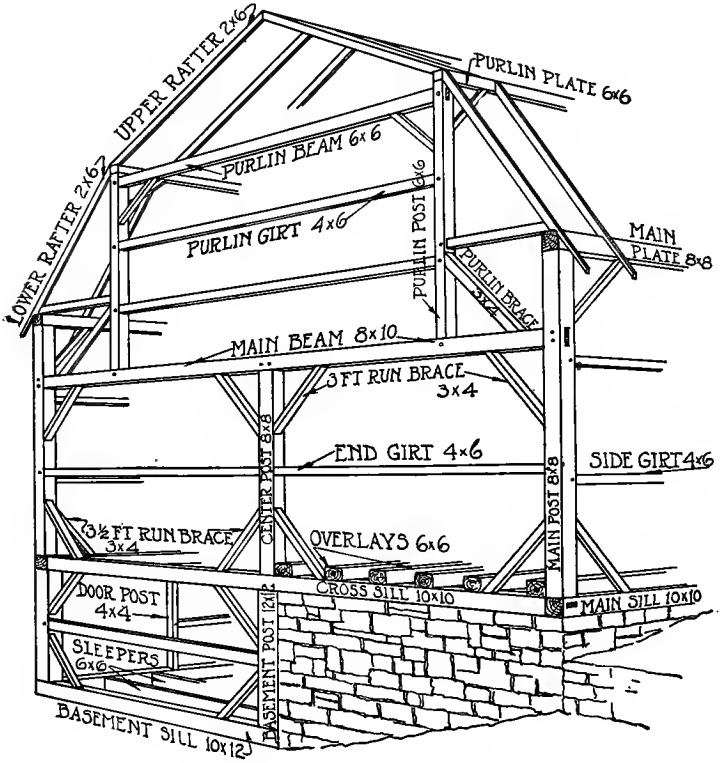


Fig. 17. Heavy Timber Barn

It must be understood, too, that there are quite a variety of ways of framing a balloon and a plank frame. It will be possible in this chapter to treat of but one type. A mastery of this one type should enable the student to work out other types, with suitable detailed drawings provided him.

10. Sills and Girders.— In Fig. 21 will be found illustrated three types of box sill construction. Whatever the sill used, care must be taken to so plan that mice may not have free access to the

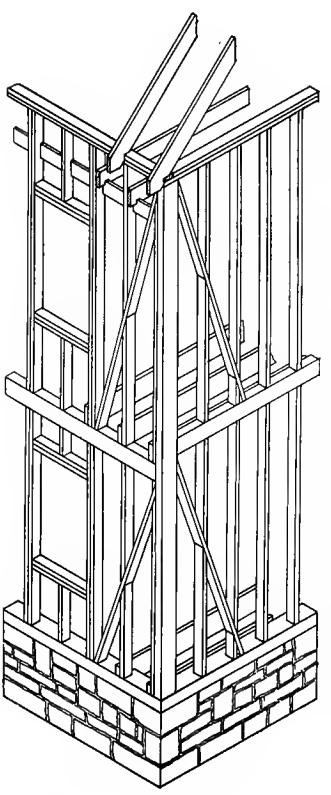


Fig. 18. Half-Frame House

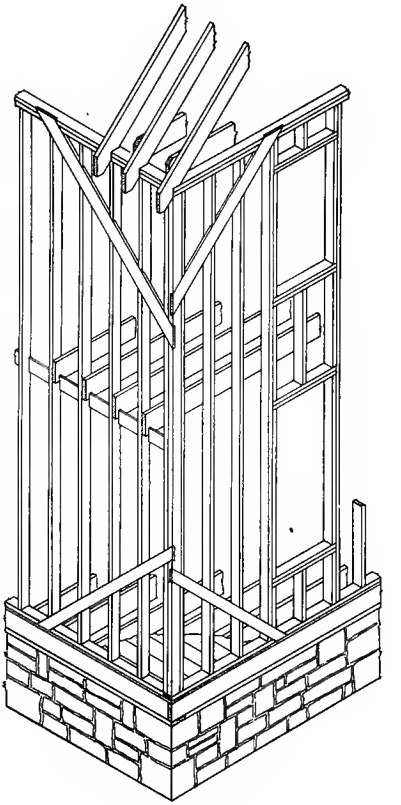


Fig. 19. Balloon Frame House

various parts of the building. If the sill does not inhibit, then blocks should be spiked between the studs. Such blocks serve as fire breaks.

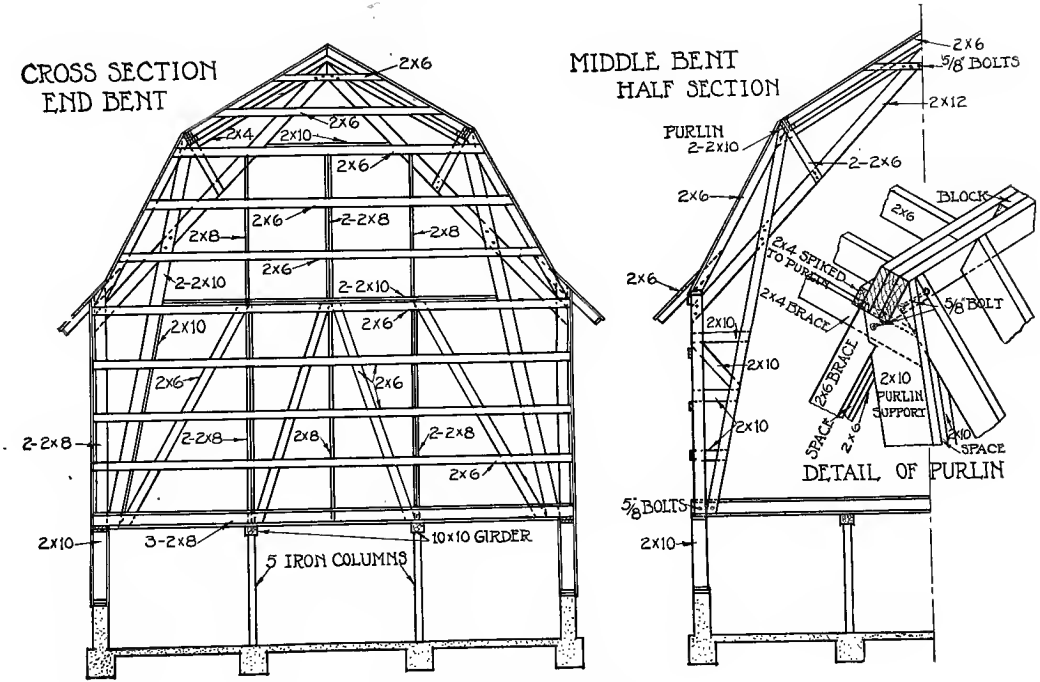


Fig. 20. Plank Frame Barn

The bed plate of the box sill should be selected from stock with straight edges. In the framing of joists, plan so that the crowning edges shall be up when in position, and in placing the joists see that the most crowning are in the middle of a room. Joists are fastened to their sills as in Fig. 21.

Fig. 22-a illustrates a built up girder, and the manner of framing the joists to it. Three 2″ x 10″'s with a 2″ x 4″ attached to each side, the whole thoroly spiked together, form the girder. The advantage of this type of girder lies mainly in the fact that it leaves the headroom of a basement clear, which is not the case in the type shown in Fig. 22–b. This second type is somewhat easier to frame, and is therefore greatly used where the owner does not object.

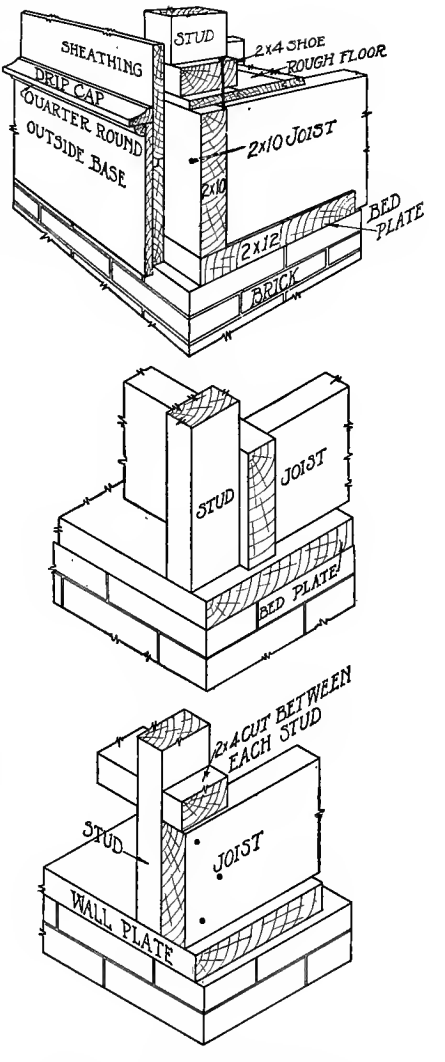


Fig. 21. Three Types of Box Sills

It is better where furnace stacks must be placed in a partition above it.

First floor joists, like second floor joists and studs, should be

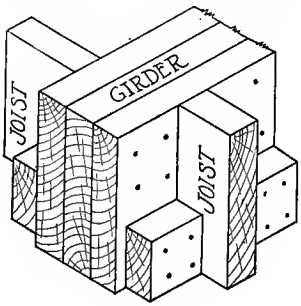


Fig. 22-a.

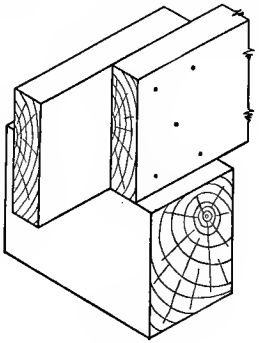


Fig. 22-b.

Girder Types

spaced 16 inches from center to center, beginning at one side or end of a room. Not to make such provision would cause a waste in lathing, since the lath are all 4 feet in length, a multiple of 16 inches. Any remainder after such a spacing should be allowed to come at the side or end of the room.

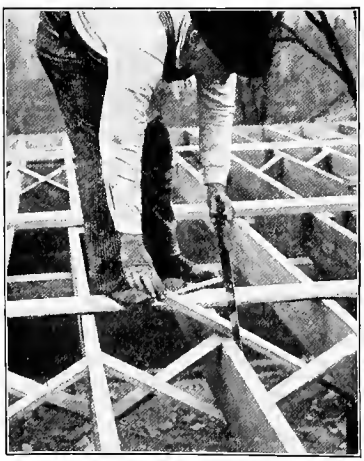


Fig. 23. Cutting Bridging

11. Bridging.—To add to the carrying power of floor joists, bridging is cut in between them as shown in Fig. 23. For ordinary dwellings 1″ x 3″ stock will serve. On large work, stock two inches thick should be made use of. Bridging should be spaced not

more than 8 feet apart. A miter-box, set at the appropriate angle, may be used in cutting bridging, all the pieces being cut at one time with the exception of those for the odd spacings at the side or end of a room. A more common practice is to take a piece of stock, and, after cutting a bevel on one end, place it as in Fig. 23 with

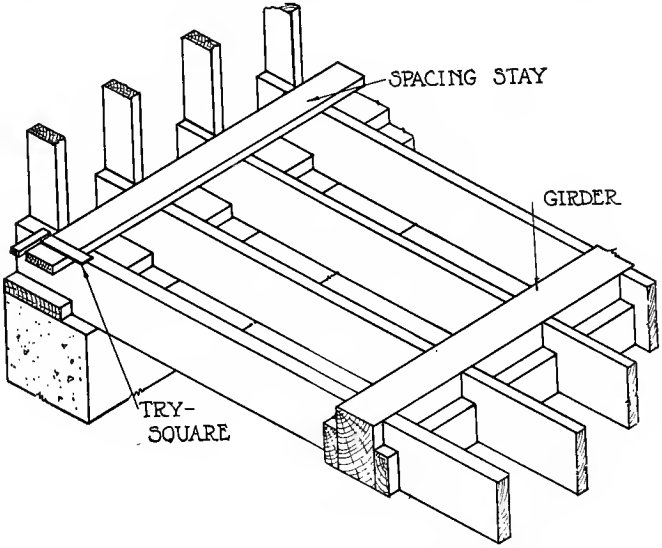


Fig. 24. Laying off a Stay

the beveled end above the lower edge of the joist against which it rests, a distance slightly in excess of the thickness of the stock; then saw as indicated, sawing vertically and along the joist.

Before placing bridging, the joist must be spaced and properly fastened in place. This is done by placing a piece of stock, 1″ x 6″ or 2″x 4″, as in Fig. 24. With a try-square, mark the locations of the joists. This board may then be transferred to the center of the room and the joists there spaced according to the marks, and held in place by being "tacked." A second method consists in

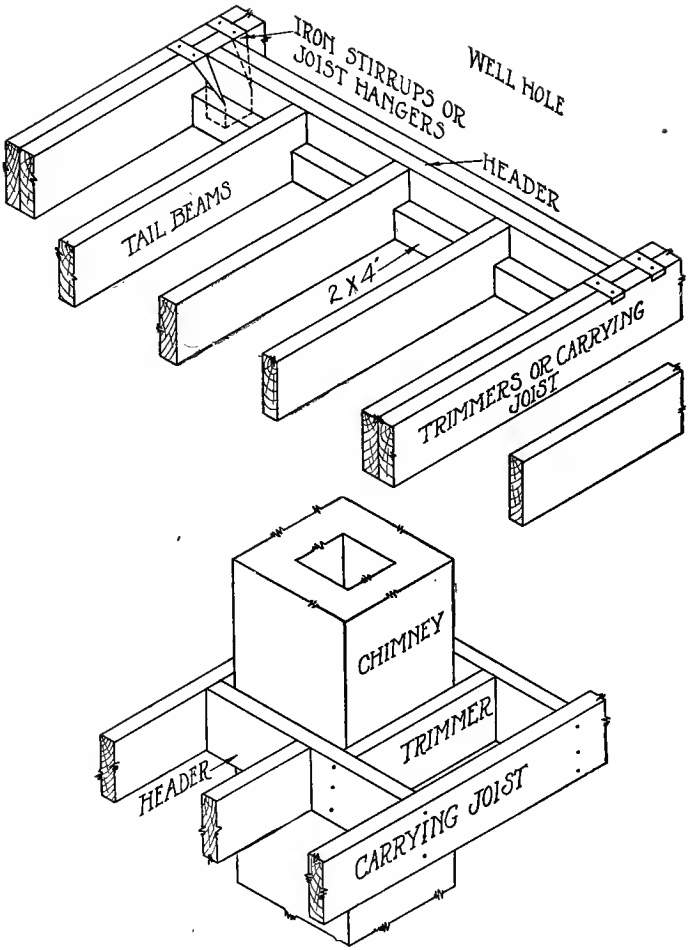


Fig. 25-a-b. Headers and Trimmers in Floor Frame

placing the spacing board in the center of the room and having a second person sight the joists for straightness while the first party places them as directed and tacks them. This tacking consists in driving the nails only partially in, leaving the heads project enough that they may later be withdrawn with a claw hammer. Still another method is to lay off the "stay" by measurement with the framing square so that it corresponds with the spacings of the joists at the side walls.

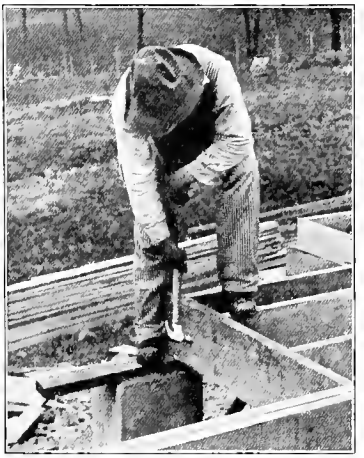


Fig. 26. Placing Headers and Trimmers

Bridging should be nailed with two nails at each end of the piece.

12. Trimmers and Headers.—In the making of stair and chimney openings it becomes necessary to support the ends of joists other than in the usual manner. This is done by cutting in headers as in Figs. 25, 26 and 27. Where the span is not great, such as at an ordinary chimney in

Fig. 27. Floor Frame and Rough Floor

residence work, in which but one or two tail beams are to be carried, headers are not doubled and are merely spiked in place. Where many joists are to be carried, headers or trimmers, or carrying joists must be doubled. Iron stirrups or hangers should be used instead of spikes in joining headers to carrying joists where spikes would weaken the carrying joist and would not give

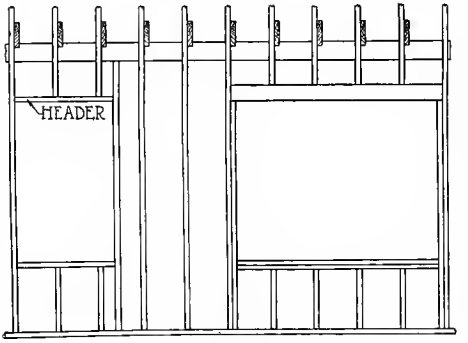


Fig. 28-a.

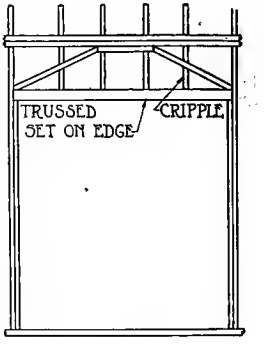


Fig. 28-b.

Headers and Trimmers in Wall Frame

sufficient strength to the joint. Except upon long spans, tail beams are usually fastened to the header by spiking only. On long spans they should be framed to the header as joists are framed to a girder, a 2″ x4″ being spiked firmly to the header as a support.

In determining the amount of space to allow for head room in framing about a well hole for a stair, determine the run and rise of the stair from the plan and elevation, and then plan to allow at least 6′ 6″, measured from the proposed nosing line of the treads up to the proposed location of the trimmer, or carrying joist, or header, as the case may be, at the ceiling level, Fig. 121.

The term "header" is also used to designate the studding, or joist in the case of double doors, placed horizontally over window and door openings, Fig. 28. Studding cut in below window open-

Fig. 29. Headers and Trimmers in Wall Frame

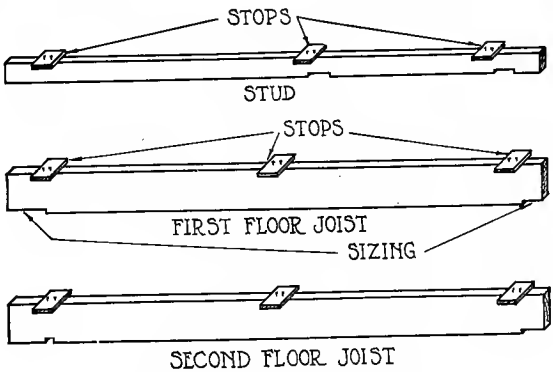


Fig. 30. Stud and Joist Patterns

ings forms the stool, also known as header. The illustration shows the manner of framing for openings of different widths. A small single window may require but one thickness of 2″ x 4″. A medium sized opening will have a header of two pieces of 2″ x 4″. Where

the opening is rather large, as in the case of double door openings, two joists will be set on edge over the opening as header.

13. Walls and Partitions; Joists and Rough Floors.— A study of Figs. 16, 17, 18, 19, 20 and 29 should give an understanding of the essential members of the framed wall of a building, and their relations one to another.

Fig. 31. Marking Joists from Pattern

Whether side walls shall be framed and raised before the rough or false floor of the first story is laid will depend upon the type of sill construction made use of.

In laying off studs, joists, etc., a pattern is first framed. These patterns are afterward used in the building and are therefore counted in with the total number of pieces to be framed. To these patterns, stops and

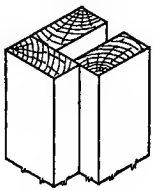


Fig. 32-a.

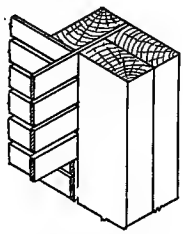


Fig. 32-b.

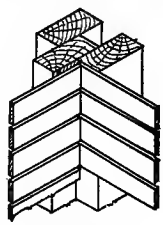


Fig. 32-c.

Corner Post Types

fences are attached near the two ends and at the middle, Fig. 30. The other studs or joists of similar dimensions are laid off one at a time by superimposing these patterns and marking about them with pencil, Fig. 31.

Ribband or ribbon boards and plates are laid off by placing them alongside the "layout" for the studs made upon the sills, and transcribing the marks to the ribband board and plate by means of try-square and pencil. Sometimes ribband boards and plates are laid off by measurement, as are sills.

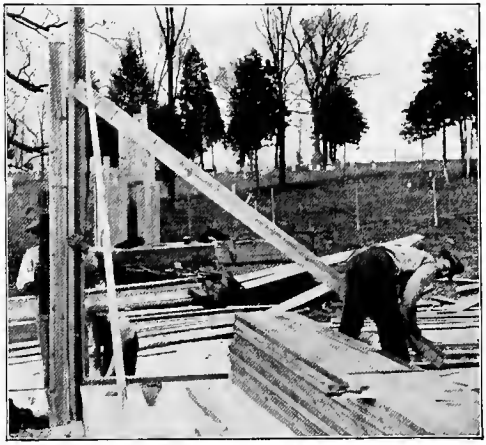


Fig. 33. Corner Post Being Plumbed and Stayed

Corner posts are constructed first and placed. Fig. 32-a shows a section of a corner post which has much to commend it. Fig. 32-b illustrates a more common type of construction. The most serious objection to this type is the fact that the post must be furred after the lather has placed the lath upon one side of the room. Corner posts are plumbed and stayed in two directions, after being raised, Fig. 33. Either 2″ x 4″ or 1″ x 6″ stock will be used for stays. With the corner posts set, the ribband boards are placed. Where the span is too long for any available length of ribband board, in laying out the ribband boards provision must be made for their "breaking" joints upon studs. These studs will be raised immediately after the corner posts, the ribband board attached to corner post and stud, after which the stud will be plumbed and stayed, Fig. 34. Studs are framed before being raised so that ribband boards may be "let into" them as shown in Fig. 34. Second and third floor joists will be notched to slip over these boards

and will be spiked to the studs in addition. Remaining studs are placed one at a time, one man setting up and nailing the foot while

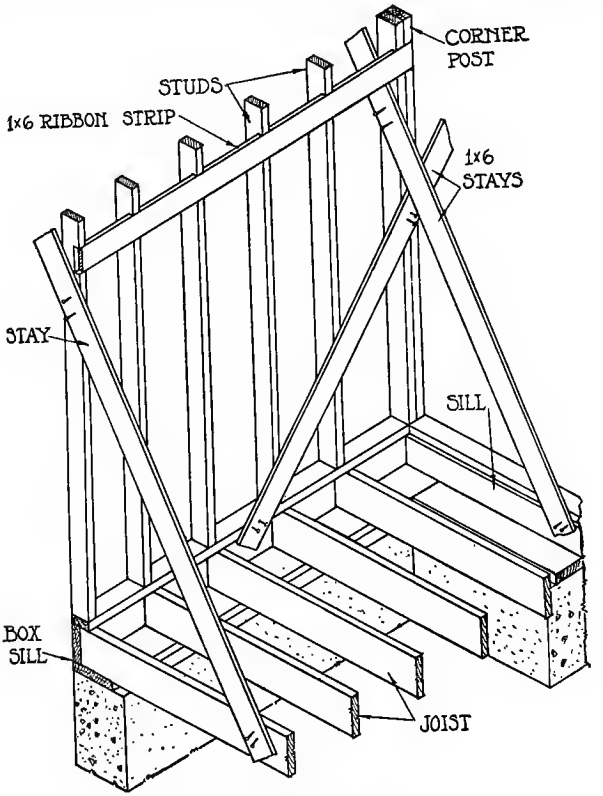


Fig. 34. Side Wall Stayed

another fastens the ribband board to the stud at the second floor line, Fig. 35.

With the completion of the raising of the two outside walls which are to bear the joist ends, the middle partition, should there be one, paralleling these walls should be framed and raised. A

slightly different procedure from that just described is followed, that is, instead of raising one stud at a time the whole partition is framed and nailed together upon the floor, even to the cutting in of headers, etc. When a section such as the number of men available can raise is ready, the same is raised, and stayed after being plumbed. The studs of partitions are framed but one story high and "plated" at such a height that second floor joists may be placed thereon in splicing. Just as far as possible first and second floor joists should be spaced to rest one directly above another and in line with the supporting studs of partitions so that furnace stacks may be placed with ease. If joists rest upon partition plates and not directly above studs, a double plate must be made use of.

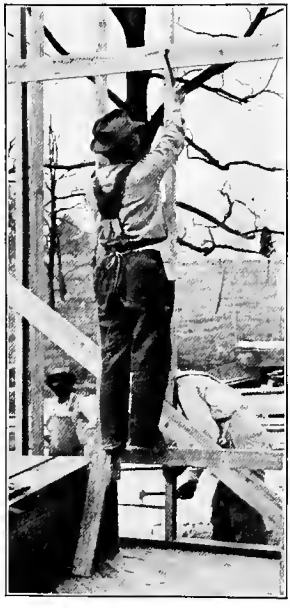


Fig. 35. Setting up Studs and Attaching to Ribbon Board

Having placed the second floor joists, the studs at the ends of the house may be set up. Their locations will be marked upon sill and upon second floor joist which is to be placed at the end of the house. This marking is best done by placing the joist upon the sill and transcribing the marks laid out upon the sill to the joist, after which it is to be raised into place.

Double plates will next be framed. They should break upon studs and be marked by transcribing the marks for the studs from the sills. At the corners the plates will be framed with butt joints, the second set lapping over the joints made by the first plate.

Next, the sustaining middle partition of the second story is raised as was that of the first story. The attic floor joists are placed as were those for the second floor.

All walls and partitions are now "lined up," that is, any irregularities are taken out by additional stays.

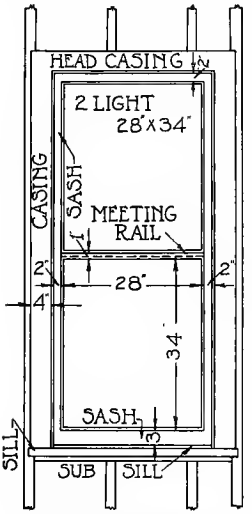


Fig. 36. Estimating Window Openings

False or rough floors are laid in the various stories where not already placed, bridging being placed and openings for stairs and chimneys framed. Such floors are laid either diagonally or straight across the joists. The diagonal floor is considered better, Fig. 27.

14. Openings in Framework.— Studs in outside walls are set without reference to openings for doors and windows. Such openings are cut and headers and stools placed after the walls are up and ready for sheathing. The seeming waste occasioned by this method is slight since the cut-out material is available for headings, etc. Most carpenters make a story pole to be used in laying off window and door heights in cutting out studs. This is nothing more than a piece of 1″ x 2″ or 1″ x 3″ stock with the heights of the openings from the rough floor or from the joists, where the rough floor is not laid, marked plainly thereon. This pole is placed alongside the stud to be cut and the mark transcribed from pole to stud.

Beginners are frequently troubled in determining the proper opening, even when the size of the window is specified. In general, carpenters plan to have the studs on either side of an opening, either door or window, so set that the outer edges of the exterior

casings will break upon their centers. Windows are specified by the width and height of their glass and the number of divisions or lights, width always being specified first. The distribution of excess measurement due to the meeting rail, top and bottom rails, side rails or stiles is shown in Fig. 36. Rail and stile widths and sash thicknesses will vary from those given when any very great

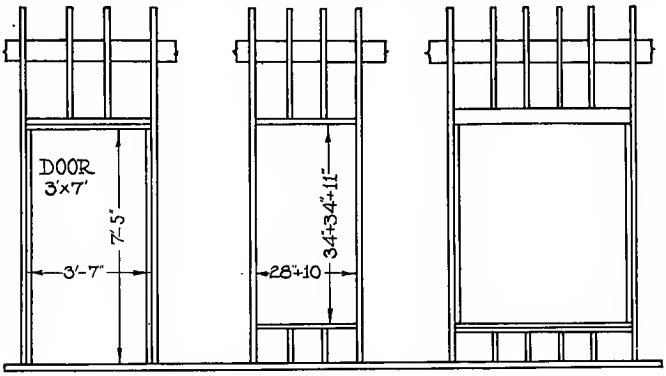


Fig. 37. Framing Wall Openings

increase in size of window is made. Manufacturers of sash and doors provide catalogs in which stock sizes are listed.

Estimate an opening vertically, Fig. 36, thus: Sill, 2″; sub-sill, where frame is made with one, 1″; bottom rail, from edge to bottom of rabbet, 3″; glass in lower sash, 34″; meeting rail, from rabbet to rabbet, 1″; glass in upper sash, 34″; top rail, 2″; space for head jamb and lugs of side jambs, 2″ or 3″; total, 79″. A carpenter would say, "Add 11″ to the glass measurement to get vertical height between stool and header." Window sashes with muntins require an addition of ¼″ for each muntin. The thicknesses of header and stool must be considered in addition to the measurement just mentioned when studs are sawed, Fig. 37.

The width between studs would be estimated thus: Width of

glass, 28″; width of stiles, from rabbeted edge to outer edge, 4″; width of casings, 8″; total 40″, distance from center of stud to center of stud. Comparing this with the width of glass it will be seen that the difference is 12″. A carpenter, therefore, makes use of a general rule: Add 10″ to the glass measurement to get distance between studs, where a 4″ or 4½″ casing is used with this type of window frame.

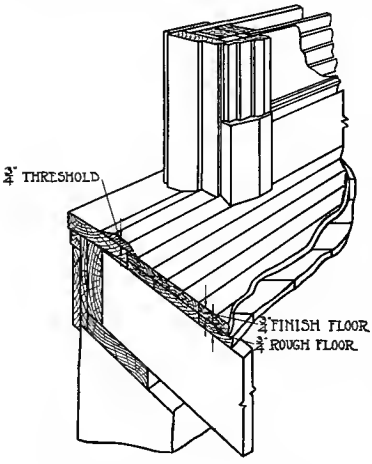


Fig. 38. Threshold Detail

For the 3′ x 7′ door, Figs. 37 and 38, estimate the opening as follows: Height of door, 7′; allowance for rough floor, ¾″; finish floor, ¾″; threshold, ⅝″ to ¾″; head jamb and space for lugs of side jambs, 2″ to 3″; total from joist, may be 7′ 5″.

For the width of opening estimate: Width of door, 3′; width of casings, at 4½″ each, 9″; total spacing of studs center to center, 3′ 9″. Distance between studs will be 3′ 7″. This will leave space enough to put the doubling studs on each side between header and floor. Since locations of openings in the main frame, both window and door, are dimensioned to the centers of the openings, it is easiest in laying off to estimate from the center each way rather than to estimate total width.

After these openings are made, the frame of the house may be covered with sheathing, or the roof may be framed; both orders of procedure are common.

CHAPTER III

Roof Frame: Square Cornered Buildings

15. Roof Framing.— The problem of framing the various members of a roof is not a difficult one provided the underlying principles are understood, and dependence placed upon this understanding rather than upon mere knowledge of what figures to use upon the square to get the cuts, without knowing why those figures

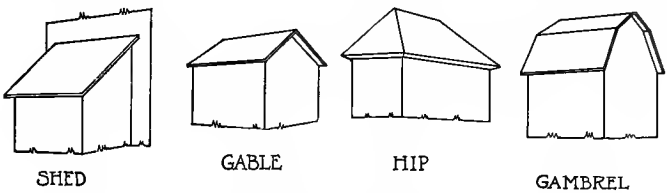


Fig. 39. Roof Types

are used. An effort will be made in this treatment to indicate the "why."

In Fig. 39 are illustrated four types of roof. Figs. 40, 41, and 42 illustrate the rafter forms and the names of the various cuts to be made in framing the members to place. The common rafter, it will be seen, has three cuts — plumb or ridge cut, seat or heel or plate cut, and end cut. The hip, valley, and jack have four cuts each; a side cut or cheek cut is possessed by each in addition to the three cuts belonging to the common rafter.

Before any rafter can be framed, the rise and run of the common rafter, in other words, the pitch of the roof, must be known.

In roof framing, the "run" of a rafter when in place is the horizontal distance measured from the extreme end of the seat to a point directly below the ridge end of the rafter, Fig. 43. The

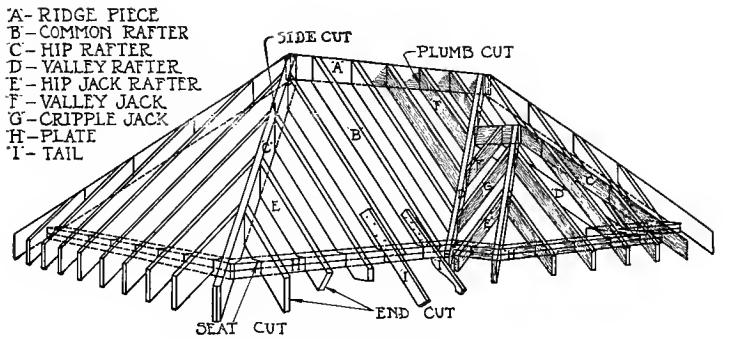


Fig. 40. Roof Details

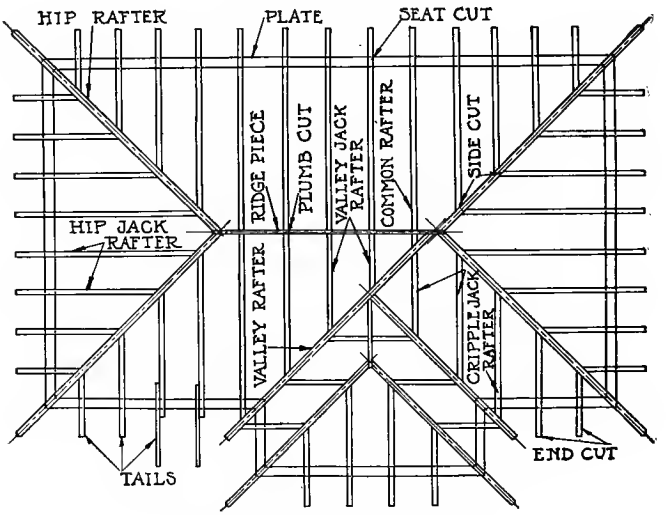


Fig. 41. Plan of Roof Rafters

"rise" is the vertical distance from the ridge end of the rafter to the level of the seat. The "pitch" of a roof or rafter is the ratio of the rise of the rafter to the span or whole width of the building.

The terms rise, run, and rafter length have still another set of

meanings — they may be used to designate "unit" lengths. In all such cases 12″ of run of the common rafter is assumed as the base, and the other unit lengths or constants are computed from this constant. The numerical values of these constants will be computed as the development of the subject of roof framing makes their use necessary.

Fig. 42. Raising the Rafters

It will be noted in Fig. 44 that the constant of run, or 12″, is taken along the tongue and the rise per foot of run along the blade of the square. It is not essential that this order be followed; the beginner will generally find it easier to visualize his work, however, if he keeps the tongue for either rise or run, and the blade for the opposite. There are occasions when the reverse order is necessary no matter which form is followed, so that it is unwise to insist upon only one way.

The variation in terminology in roof framing is so general that the beginner will do well to familiarize himself with the most com-

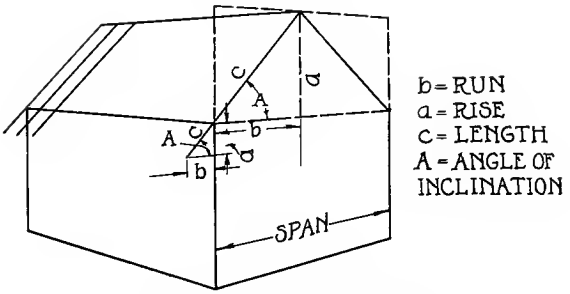


Fig. 43. Run, Rise and Length

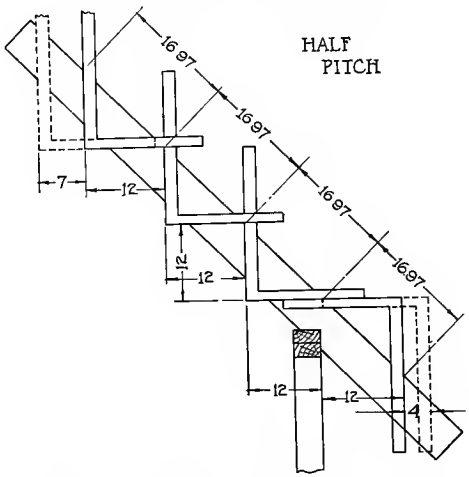


Fig. 44. Unit Length of Common Rafter

mon. Hereafter an effort will be made to confine the text to the following: plumb cut, seat cut, end cut, side cut.

The value to a beginner of a carefully made plan of a roof to be framed with necessary data such as rafter lengths and positions indicated thereon, cannot be too strongly emphasized. Architects not infrequently prepare elaborate and complete framing plans for the use of the carpenter. Upon intricate plans, experienced men

prepare plans before attempting to frame the same. Fig. 41 illustrates a framing plan ready for the placing thereon of the necessary data, such as measurements along the plate for spacing the rafters, lengths of rafters, ridge pieces, etc.

16. Framing the Common Rafter; Laying out the Plumb Cut. — While in this discussion the plumb cut is first described, it should

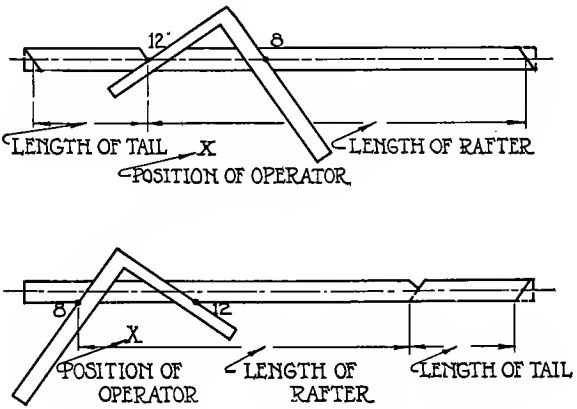


Fig. 45-a-b. Laying off Common Rafter

be understood that it is equally as convenient and more common among carpenters to begin the framing of the members of a square cornered roof frame with the end and seat cuts. In framing other than a square cornered roof it is somewhat more convenient to begin with the plumb cut.

The method of framing of the common rafter is the same for all buildings, whether the buildings have four sides or more or less. (1) Place the framing square as in Fig. 45-b, taking 12″ on the tongue as the run, and upon the blade the rise in inches per foot of run. Keep these numbers against the crowning, or what is to become the top edge of the rafter, and scribe along the blade. This gives

the plumb cut. Occasionally a carpenter will be found who frames to a center line rather than the top edge of a rafter.

Figs. 45, 46 and 47 illustrate the proper position of the worker relative to his work. Such a position will seem awkward to the

Fig. 46. Position in Laying off Plumb Cut when Laid off before Seat Cut

beginner but he should learn to visualize his work while in this position that the efficiency of framing may not be reduced thru the awkward position first likely to be assumed.

Fig. 47. Laying off Plumb Cut when Seat Cut is First Laid off

17. To Find the Length of a Common Rafter.— *First Method:* The theoretic length of a rafter is indicated by the center lines in Figs. 45-a and 48. In estimating the total length of stock for a rafter having a tail, the run of tail or length of lookout must be considered.

The pitches most commonly used are the half, third, and quarter. From an examination of Fig. 43 it will be seen that the length of a common rafter is the hypotenuse of a right triangle whose legs are the rise and the run of the roof. The problem, then,

of finding the length of a common rafter when the rise and run are known is merely that of solving the equation $c^2 = a^2 + b^2$.

Practical carpenters would not consider it economy to take time to solve for rafter lengths in this manner, for every variation in rise or run would necessitate a rather long solution. Instead, they have discovered that for every foot of run of a rafter the

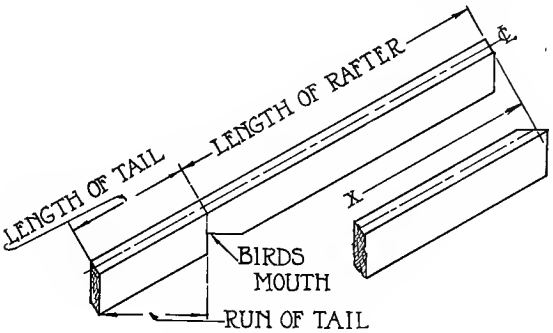


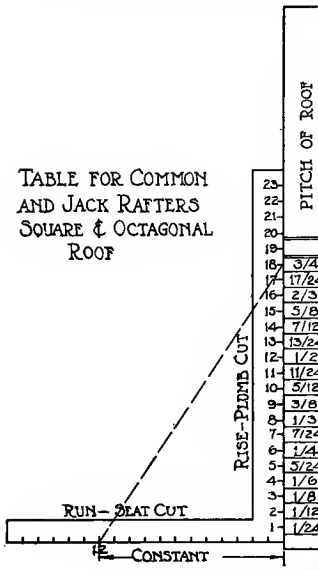
Fig. 48. Rafter Length

length of the rafter increases proportionately, the ratio of rise to run remaining the same, Fig. 44. With a table, therefore, in which the length of rafter for each foot of run, for each of the common pitches is given, the length of rafter for any given pitch can be found by merely multiplying the constant given by the amount of run for that particular rafter.

Fig. 49 shows such a table worked out for a rather extended number of pitches. From this table it will be seen that the number to take as a constant for the run is 12″, and that the rise in inches per foot of run is taken upon the other member of the framing square. A jack rafter as will be illustrated later is but a shortened common rafter, therefore, what is said of the common rafter is also true of the jack rafter. The jack, however, has an additional cut which will be discussed in another section.

Example:

Determine the length of a common rafter of a house with a 25′ span and a quarter pitch, without tail.



PITCH OF ROOF	PLUMB CUT (IN DEGREES)	SEAT CUT (IN DEGREES)	LENGTH OF COMMON OR JACK RAFTER PER FOOT OF RUN	SIDE CUT OF JACK FOR SQUARE CORNER	SIDE CUT OF JACK FOR OCTAGON CORNER	DIFFERENCE IN LENGTH OF JACKS FOR SQUARE CORNER-SET 16" CENTERS	DIFFERENCE IN LENGTH OF JACKS FOR SQUARE CORNER-SET 24" CENTERS
	° ′	° ′	Inches	° ′	° ′	′ ″	′ ″
3/4	33-40	56-20	21 63	28-0	13-0	2-4 5/8	3-7 1/4
17/24	35-10	54-50	20 81	30-0	13-20	2-3 3/4	3-5 5/8
2/3	36-50	53-10	20 00	31-0	14-0	2-2 3/4	3-4
5/8	38-40	51-20	19 21	32-10	14-30	2-1 5/8	3-2
7/12	40-40	49 20	18 44	33-0	15-0	2-0 5/8	3-0
13/24	42-40	47-20	17 69	34-10	15-40	2 3 5/8	2-11 3/4
1/2	45-0	45-0	16 97	35-20	16-20	22 3/4	2-10
11/24	47-30	42-30	16 28	36-20	17-0	21 3/4	2-8 1/2
5/12	50-10	39-50	15 62	37-30	17-40	20 7/8	2-7 1/4
3/8	53-10	36-50	15 00	38-40	18-20	20″	2-6
1/3	56-20	33-40	14 42	39-50	19-0	19 1/4	2-4 1/2
7/24	59-40	30-20	13 89	41-0	19-40	18 1/2	2-3 3/4
1/4	63 30	26-30	13 42	41-50	20-20	17 7/8	2-2 3/8
5/24	67-20	22-40	13 00	42-40	21-0	17 3/8	2-2
1/6	71-30	18-30	12 65	43-30	21-30	16 7/8	2-1 5/8
1/8	76-0	14-0	12 37	44-10	21-50	16 1/2	2-0 3/4
1/12	80-30	9-30	12 17	44-30	22-10	16 1/8	2-0 1/4
1/24	85-10	4-50	12 04	44-50	22-20		
			12 00	45-0	22-30		

Take 12 on the Tongue and Length of Common Rafter on Blade Scribe on Blade

Take 5 on the Tongue and Length of Common Rafter on Blade Scribe on Blade

Difference in Length of Jacks for Octagon Corner = 12/5 that of Square

Fig. 49. Framing Table for Common Rafter

Solution:

Run = $12\frac{1}{2}'$

Length per foot of run for quarter pitch = 13.42″

$12.5 \times 13.42'' = 167.75'' = 13.98'$

(Looking for the nearest fractional value of .98 in the Table of Decimal Equivalents in Appendix III, $\frac{63}{64}$ or practically 1′)

The rafter would be framed 14′ in length.

When a tail is a part of the rafter, proceed in the manner described adding the run of the tail, or length of lookout, to the run of the rafter.

Fig. 50 shows a framing square, containing among other data, the rafter lengths per foot of run. To use the data pertaining to

common or jack rafter lengths, (1) consider the run as 12″ taken on the tongue; (2) select upon the blade along its outer edge the inch mark which represents the rise of the roof per foot of run required to give the pitch specified; (3) the number directly below this

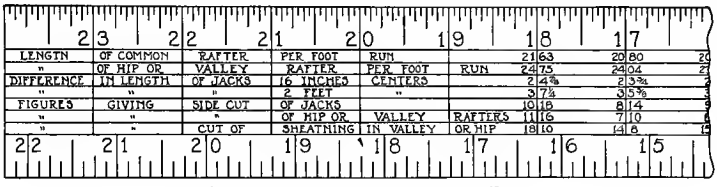

LENGTH OF COMMON RAFTER PER FOOT RUN
" OF HIP OR VALLEY RAFTER PER FOOT RUN
DIFFERENCE IN LENGTH OF JACKS 16 INCHES CENTERS
" " " 2 FEET "
FIGURES GIVING SIDE CUT OF JACKS
" " " OF HIP OR VALLEY RAFTERS
" " CUT OF SHEATHING IN VALLEY OR HIP

Fig. 50. Framing Square Detail

mark, reading across the blade in the space marked "Length of Common Rafter Per Foot of Run" gives the length per foot for that particular rise or pitch.

As a check for rafter length computations, the following procedure is suggested: Selecting the run as 12″ on the tongue and the rise in inches per foot of run on the blade, place one square upon another as shown in Fig. 51, using that side of the square divided into inches and twelfths. Do not use the end of the blade, the rounded corner makes it impossible to secure the accuracy demanded. Extreme accuracy is required if the constant is to be used for rafters of considerable length of run. Read the diagonal length between the numbers representing the run and rise. Read the whole number of inches as feet, and the fractions as inches, and take off any fractional remainder upon a very sharp pointed pair of dividers. Read this divider spacing by means of the hundredths scale on the framing square. The result should, if the work is very accurately done, be the same as that obtained by computation from the tables, even to the hundredths place decimal. Upon ordinary work where great accuracy is not required carpenters sometimes determine this constant for a given pitch by placing the framing square as in Fig. 46 or 47, taking upon the tongue the run and on the

blade the rise, marking along both tongue and blade. The distance between these marks is then read on a square placed along the edge.

Second Method: In determining rafter length, an equally common practice is to lay the framing square as is shown in Fig. 45-a. While in this position the seat cut is scribed, cf. Section 18, and also a short sharp line scribed along the other member of the square at the top edge of the rafter. The square is moved along, using the same numbers, and another advance mark scribed. This operation is repeated just as many times as there are feet in the run of the common rafter. With a span of 24′ the operation would be repeated 12 times.

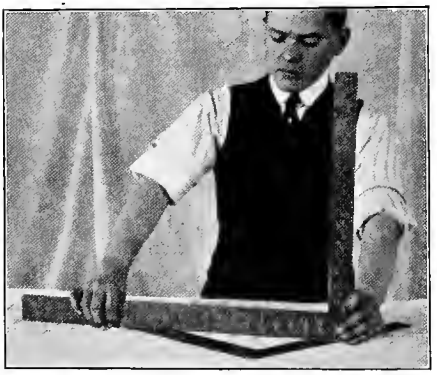


Fig. 51. Finding Rafter Length by Scaling

Should the run not happen to be in even feet, the square would be placed as many times as there were full feet in the run. In addition it would be advanced that fractional part which the fraction of the run was of 12″. For example, in a run of 12′ 7″, with a roof of ¼ pitch, the square would be advanced 12 times using the number 12 on the tongue and 6 on the blade. In addition to this the square would be advanced using $\frac{7}{12}$ of 12″ or 7″ on the tongue and $\frac{7}{12}$ of 6″ or 3½″ on the blade. As these numbers do not allow enough of the square to rest on the rafter to give a full line, as soon as the advance limit of rafter length is indicated the square may be moved up, using the set of numbers first used, that is 12″

and 6″. On common rafters, this last operation is simplified by noting that the fractional run, divided by 12, times 12, always equals itself. The final position of the square, therefore, may be obtained by simply sliding the member, used in laying out the last full foot line which parallels the seat cut, an additional dis-

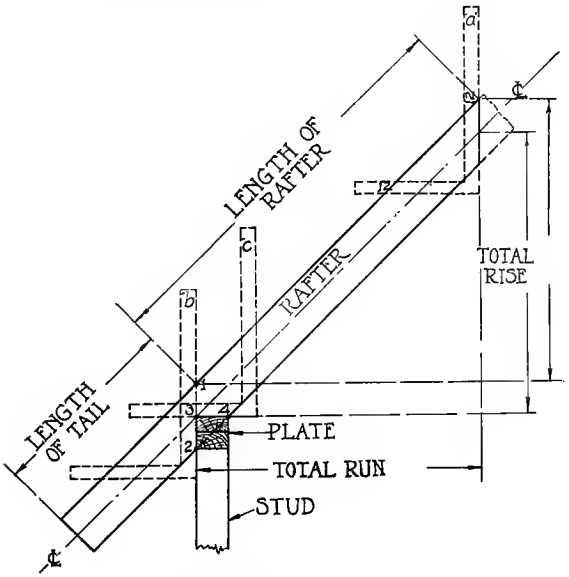


Fig. 52. Laying out Rafter

tance equal to the fractional foot of total run, Fig. 44. The tail length is obtained similarly, Fig. 44.

18. Laying off Common Rafter Seat Cut and End Cut.— *First Method:* Having determined the rafter length as directed in Sec. 17, first method, (1) lay off this length along the upper edge beginning at the plumb cut. The whole number of feet is more safely "taken off" by means of a pole marked in feet, and of good length. The rule or square may be used to transmit fractional parts of a

foot. (2) Place square as at "b," Fig. 52, standing as in Fig. 45-b, and scribe a plumb line as indicated at 1–2, Fig. 52. (3) From the point 1, Fig. 52, measure along the line marked 1–2 a distance equal to one-half that of 1–2. The distance 1–3 may be increased or decreased somewhat when an extreme pitch makes it advisable. As a rule this should be $2\frac{1}{2}''$ to $3''$. (4) Place the square as at *c*, Fig. 52, with the edge of the tongue resting on 3 and scribe a line for

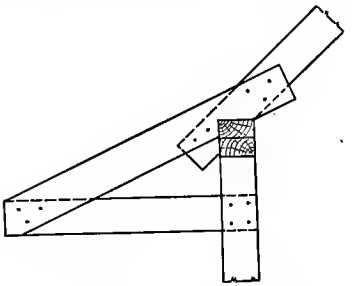


Fig. 53. Independent Rafter Tail

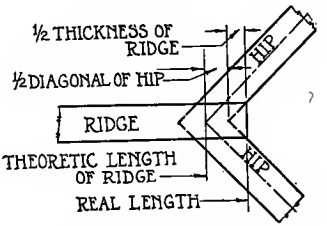


Fig. 54. Length of Ridge Piece

the seat cut, as 3–4. These last marks give the bird's mouth joint which is to fit over the plate.

While many carpenters allow end cutting of the rafter tails to wait until the rafters are set in place so that they may be lined and cut while in position, certain kinds of work permit the ends to be cut at the same time the remainder of the rafter is framed. In this latter method the square is placed as in Fig. 44 and (5) the end cut scribed. The point of cutoff on the tail is determined in the same manner as that used in determining rafter length, the run of the tail being considered and the tail length being measured from the point 1, Fig. 52.

Where a cornice is of unusual width, tails are usually framed independent of the rafters and are then spiked to the ends of the rafters either above or below the plate, Fig. 53.

Second Method: Where the second method of finding length, Section 17, is employed, the end cut and seat cut will be laid out before the plumb cut. The operator will stand as in Fig. 45-a.

When one rafter has been laid out it is cut and used as a pattern by which to cut similar rafters.

19. Ridge Piece.— Roofs may be framed with or without a ridge piece. The use of a ridge piece makes the assembly or raising

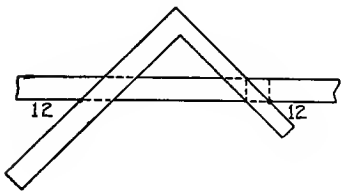


Fig. 55. Determining Diagonal Thickness of Hip of Square Corner.

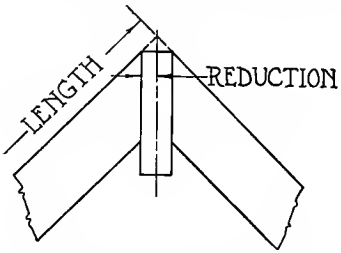


Fig. 56. Reduction of Common Rafter for Ridge Piece.

of a roof somewhat easier, especially a hip roof. Upon an ordinary dwelling a ridge piece is usually a 1″ x 6″ board. Upon a gabled roof the length of ridge piece will be the same as that of the plate which it is to parallel, and will be laid off by placing the ridge board alongside the plate after the rafter positions have been marked upon the plate. These marks are transcribed upon the ridge board by means of the square and pencil.

On a hip roof, Fig. 54, the length of a ridge piece will be equal to the length of the parallel plate diminished by the length of the plate at right angles to this. This, however, is the theoretic length of ridge as measured from center to center. Enough extra stock must be left on the ridge when framing it to allow full contact of hip cheeks. This additional measurement at each end of the ridge will be equal to ½ the diagonal thickness of the hip plus ½ the thickness of the ridge, Fig. 54, making a total addition equal to the

diagonal thickness of the hip plus the thickness of the ridge. Fig. 55 illustrates the placing of the square to determine the diagonal thickness of a hip rafter which strikes the ridge at an angle of 45 degrees.

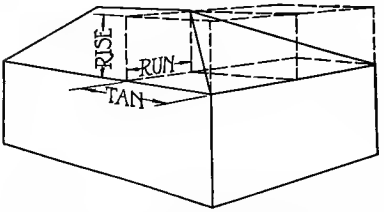


Fig. 57. Hip or Valley Rafter is Diagonal of Square Prism

In reckoning the length of a common rafter which is to rest against a ridge, the total length must be reduced by an amount equal to one-half the thickness of the ridge measured at right angles to the plumb cut, Fig. 56.

20. Hip and Valley Rafters of Square Cornered Buildings.—*First Method:* The line of measurement for length of a hip and

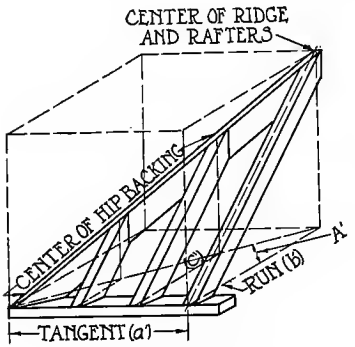


Fig. 58-a. Hip Rafter.

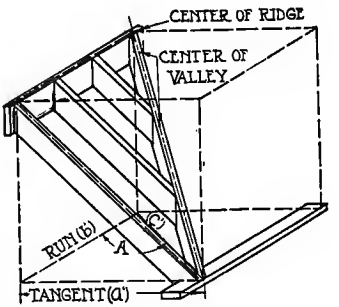


Fig. 58-b. Valley Rafter

valley rafter is along the middle of the back or top edge, as on common and jack rafters. The manner of determining the number to use on the tongue of the square as a constant for the run, in terms of the 12″ constant run of the common rafter, when the rise of the hip or valley rafter per foot of common run is taken on the blade; and the manner of constructing a table of unit lengths of hip

and valley rafter, per foot of run of common rafter, are illustrated in Figs. 57, 58, 59 and 60. From a study of these illustrations it will be seen that a hip or valley rafter of a square cornered building is in either case the diagonal of a square prism which has for its base dimensions the tangent and run of the roof, and for its height the rise of the roof, Fig. 57. On a square cornered building the run and tangent are always equal.

The length of the diagonal of the base of such a prism, which is the run of the hip or valley rafter, is found by the formula $c'^2 = a'^2 + b'^2$, Fig. 58. When tangent and run are equal and each taken as 12″, the run of the hip or valley equals 16.97″, which for practical purposes of carpentry is considered as 17″. In laying on the square, then, in framing a hip or valley rafter of a square cornered building, 17″ will be taken upon the tongue, the rise of the roof per foot of run of common rafter or per 17″ of run of hip or valley rafter, being taken on the blade.

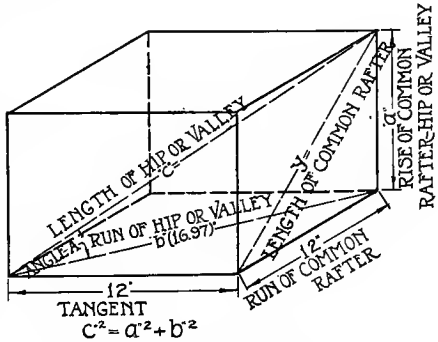


Fig. 59. Determining Unit Length of Hip or Valley Rafter.

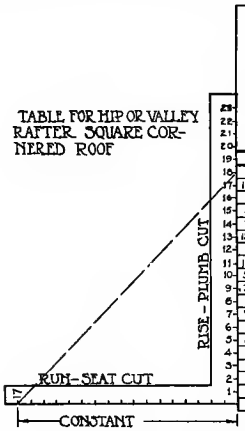
The table of hip and valley lengths per foot of run of common rafter, Fig. 60, will be formed by solving the right triangle $c''^2 = a''^2 + b''^2$, Fig. 59, for each of the pitches represented.

The positions to be assumed by the worker in framing a hip or valley rafter are similar to those to be assumed in framing the common rafter.

In measuring the length of a hip or valley rafter by the first method, the plumb cut may be laid off first. The upper end of the

hip rafter will have to be framed with a side cut as shown in Fig. 61. The measurement for length will be made from a point along the middle of the top arris. Where the second method is employed, the end and seat cuts are laid off first.

21. Laying off Plumb Cut of Hip or Valley Rafter for Square Cornered Buildings.— Assuming a position with reference to the rafter similar to that in framing the common rafter, lay off the plumb cut using 17″ on the tongue, and on the blade the rise per



PITCH OF ROOF	PLUMB CUT (IN DEGREES)	SEAT CUT (IN DEGREES)	LENGTH OF HIP OR VALLEY PER FOOT OF RUN OF COMMON RAFTER	SIDE CUT OF HIP OR VALLEY RAFTER	BACKING OF HIP IN DEGREES	AMOUNT OF 'DROP' OF HIP NO BACKING
	° ′	° ′	INCHES	° ′	° ′	INCHES
3/4	43-20	46-40	24 72	34-30	53-30	7/8
12/24	45-0	45-0	24 00	35-20	54-40	3/4
2-3	46-40	43-20	23 31	36 0	55-30	5/4
5/8	48-30	41-30	22 64	36-50	56-30	11/16
7/12	50-30	39 30	21 98	37-40	57-20	5/8
13/24	52-30	37 30	21-37	38 20	58-40	5/8
1/2	54-50	35-10	20-78	39-10	59-30	9/16
11/24	57-10	32-50	20-22	40-0	61-30	1/2
5/12	59-30	30-30	19-69	40-50	63-10	7/16
3/8	62-10	27-50	19-21	41-30	64-50	7/16
1/3	64-50	25-10	18-76	42-10	67-00	3/8
7/24	67-30	22-30	18-36	42-40	69-10	5/16
1/4	70-30	19-30	18-00	43 20	71-30	5/16
5/24	73-40	16-20	17-69	43-50	74-10	1/4
1/6	76-40	13-20	17-43	44-10	77-00	3/16
1/8	80-00	10-00	17 23	44-30	80-10	1/8
1/12	83-20	6-40	17-09	44-50	83-20	1/8
1/24	86-40	3-20	17-00	45-00		1/16
			16-97	45-00		

TAKE 17" ON THE TONGUE AND LENGTH OF HIP OR VALLEY ON BLADE - SCRIBE ON BOTH

TAKE RISE ON THE TONGUE AND LENGTH OF HIP OR VALLEY ON BLADE - SCRIBE ON TONGUE

Fig. 60. Framing Table for Hip or Valley Rafters

foot of run of the roof, or common rafter, which is also the rise of a hip or valley on that roof per 17″ of hip or valley run. Scribe along the blade.

22. Side or Cheek Cut of Hip or Valley Rafter.— *First Method:* There are a number of ways to lay out a side cut on a square cornered building. The simplest to remember, where no framing tables are at hand, consists in measuring square back from the plumb cut line a distance *A*–*B*, Fig. 62, equal to the thickness of the rafter being framed. Thru this point lay off another line parallel to the plumb cut line and "carry" this across the top edge

of the rafter with the square, as at D–E. Now adjust the bevel to pass thru E and F, Fig. 62, and the setting is obtained for all side cuts of hip or valley rafters of that pitch of roof. Scribe this line on the top edge of the rafter. Carry it down the remaining side using the same numbers on the square as were used in laying off the plumb cut on the first side.

Second Method: This method of laying off side or cheek cut consists in laying the framing square across the top edge of the

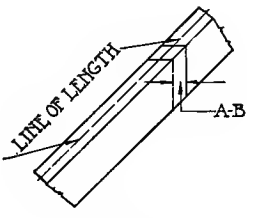


Fig. 61. Side Cut

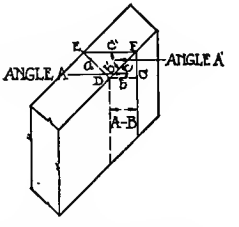


Fig. 62. Laying off Side Cut

rafter, taking 17″ on the tongue and the length of hip or valley rafter per foot of run of common rafter for the pitch required on the blade, and scribing along the blade.

23. Determining Length of Hip or Valley Rafter.— *First Method:* If a table of unit lengths of hip or valley per foot of run of common rafter is available, Fig. 60, the total rafter length may be determined by multiplying the unit of hip or valley rafter length per foot of run of common rafter by the total run of common rafter. Do not make the mistake of trying to multiply by the run of the hip or valley rafter. Remember that these tables are all worked out with the 12″ run of the common rafter as the base. This is true no matter whether the house is four sided, eight sided, or any other number of sides. The respective tables are based in every case upon 12″ run of the common rafter.

Measurements for lengths of hip or valley are to be made along

the top edge of the stock beginning at the line for side cut and midway between the point and heel, Fig. 61.

Second Method: This method of determining length of a hip or valley rafter is not unlike the second method described for the common rafter. Here, the numbers are 17 on the tongue, and the rise per foot of run of roof or of common rafter, on the blade. The end and seat cuts are scribed, after which the square is advanced step by step, using these same numbers, as many times as there are feet of run of common rafter. Should there be a fraction of a foot in the run of common rafter an additional and proportional advancement must be made. For example, to frame a hip for a square roof of ¼ pitch, having a run of common rafter of 12′ 7″. Advance the framing square 12 times, using 17″ on the tongue and 6″ on the blade. For the fractional advance take $\frac{7}{12}$ of 17″ or $9\frac{1}{12}$″ (the framing square is laid off in twelfths on one side) on the tongue and $\frac{7}{12}$ of 6″ or $3\frac{1}{2}$″ on the blade, and scribe the limit. Fractional foot length of tail will be determined in a similar manner, the run or horizontal extension, or the lookout, of the common rafter determining the number of times the square must be advanced using 17″ and 6″ for the above given pitch.

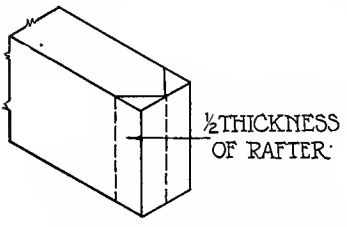


Fig. 63. Miter Cut of Hip Rafter End

24. Laying off Seat and End Cut of Hip Rafter for Square Cornered Building.— The seat cut and end cut of a hip rafter will be laid off in a manner quite similar to that used in laying off the seat and end cuts of the common rafter as described in Sec. 18. There will be this difference, of course; the numbers to be used on the square will be 17″ on the tongue instead of 12″ as in the case of the common rafter. The rise per foot of run will be the same as

for the common rafter. The run of the tail of the common rafter determines the length of lookout or the number of times the square will be advanced. The distance 1–3, Fig. 52, must be the same on hip and valley as on common rafter of the same pitch of roof. The end cut of a hip rafter must be mitered to receive the fascia. The amount to be taken off for a square cornered building will be indicated by laying off lines a distance equal to one-half the thickness of the rafter, measured straight back from the lay-out of the end cut, Fig. 63. Since these cuts are identical with the side cut at the upper end of hip or valley, the square may be used as in laying off a side cut, cf. Section 22, second method.

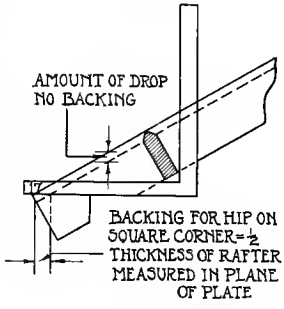


Fig. 64. Backing the Hip Rafter

25. Reduction of Hip or Valley Rafter Length Because of Ridge Piece.— If a hip rafter of a square cornered building is to be framed against a ridge piece, Fig. 40, its length must be reduced correspondingly. To make such allowance, measure square back from the line of plumb cut a distance equal to ½ the diagonal thickness of the ridge, Fig. 61-A–B.

26. Backing a Hip Rafter for Square Cornered Building.— *First Method:* Since the line of measurement of a hip rafter is along the center of the top edge, if the rafter is framed with the same plumb distance as was given the common rafters, 1–3, Fig. 52, it stands to reason that the roof boards will not fit the top edge of the hip properly until the arrises of the hip have been removed as in the cross-section of Fig. 64. The laying out and removal of these arrises is known as backing the hip.

The amount of backing for a hip rafter will depend upon the rafter thickness, the pitch of the roof, and the number of sides to

the plate, and is indicated by gage lines on either side and one on the top edge of the rafter. To determine the location of these gage lines on the sides of the rafter, (1) place the square on the hip as in laying out the seat cut for the hip on which the backing is to be placed, the constant, 17″, on the tongue and the rise on the blade, if the house is rectangular, Fig. 64. (2) Measure from the edge of

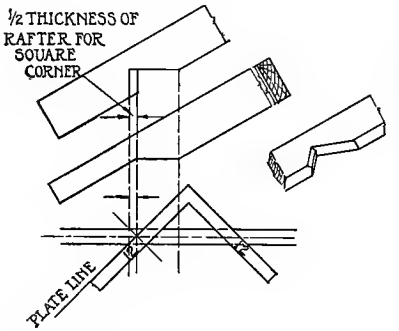


Fig. 65-a.

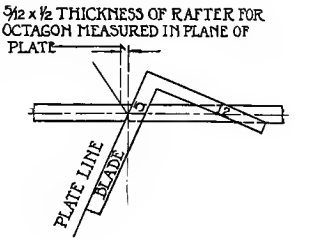


Fig. 65-b.

Framing Valley Rafter at Plate

the hip back along the tongue a distance equal to ½ the thickness of the rafter, and mark. This point gives the setting for the gage. (3) Gage both sides of the rafter and then remove the arrises as shown in the cross-section. Carpenters more frequently frame a hip without backing, allowing the roof boards to rest upon the arrises of the hip, forming a small triangular space between the roof boards and the top edge of the hip. In order to keep these arrises in the same planes as the tops of the common rafters, they must reduce the plumb height 1–3, Fig. 52, of the hip. The amount of reduction, that is, the amount of drop the hip must make is equal to the plumb height of the backing, Fig. 64.

Second Method: Take the rise in inches per foot of run of common rafter on the tongue, and the length of hip or valley per foot

of run of common rafter on the blade; scribe along the tongue to get the angle of backing.

27. Valley Rafters.— As has been indicated in previous sections of the text, valley rafters have their lengths, plumb cuts, and seat cuts determined like hip rafters.

There is one difference; the valley rafter at its seat must be framed as in Fig. 65 in order that the plumb line may come directly over the corner of the building. The ends of roof boards will rest upon the valley rafter at its center line, which line is in the same plane as that of the common rafters.

Like the hip rafter, the upper end may be laid out first, after which the rafter length is measured from this, the measurement being made along the middle of the back of the rafter, the top edge.

To lay out the cuts shown in Fig. 65-a, proceed as in laying out the end of a hip rafter, as described in Sec. 24, Fig. 63. In the case of an octagon the amount would be $\frac{5}{12}$ of that used for the square, Fig. 65-b.

In Figs. 40 and 41 is shown a valley rafter framed thru to the ridge. This is done to give the valley support, for a valley, unlike a hip, is not self supporting when the jacks are attached. Against this valley rafter is framed a second valley rafter. The upper end of this second valley rafter is framed with a plumb cut such as would be given a hip or valley of the same rise and run; the end, however, is cut square across as in the case of a common rafter resting against a ridge.

28. Framing the Jack Rafter for Square Cornered Buildings; Plumb Cut; Side Cut.— Jack rafters which have their top ends framed against a hip are known as hip jacks; those having the lower ends framed against a valley are known as valley jacks; those which are framed in between hip and valley are known as cripple jacks.

The jack rafter, being but a portion of a common rafter, is

framed in a manner quite like that used in framing the common rafter. The chief difference is in the fact that the jack rafter has a side or cheek cut, and that the lengths of jacks vary with their position along the plate. The order of procedure may be: (1) To lay off the plumb cut, just as for a common rafter having the same rise, that is, using 12″ on the tongue, and the rise per foot of run on the blade; scribe along the blade. (2) Lay off the side cut or cheek cut. This is done just as in laying off the side cut of the hip rafter on a square cornered building, first method only, Fig. 62. Where a table of common rafter lengths per foot of run is available, Fig. 49, a second method of laying out the side cut of a jack rafter consists in taking 12″ on the tongue of the framing square, and the common rafter length per foot of run for the pitch given, on the blade; laying the square across the edge of the rafter and scribing along the blade. (3) Lay off the length of the jack as determined in the next section. (4) Lay off the seat cut just as in laying off the seat cut of the common rafter for the same pitch of roof, Section 18. Equally common is the practice of beginning with the end and seat cuts.

The framing square of Fig. 50 contains data which makes possible the laying out of side cuts for the square cornered building by means of numbers taken upon tongue and blade.

While the ratios of the numbers used upon the tongue and the blade are always the same for any given pitch, different makers of squares use different numbers for side cuts. The student will have to have special directions for each different make of square. These may be gotten from the manufacturers.

29. Lengths of Jack Rafters for Square Cornered Roofs.—*First Method:* The framing table for common rafters and jack rafters, Fig. 49, may be made use of in determining lengths of jacks. To make use of this table we shall need to know the run of each separate jack. An examination of Fig. 66 shows that in a rectangular house the run of a jack is the same as the length of plate

or of ridge which forms the angle. This is true of hip jack, valley jack, or cripple jack. However, such measurements are along the centers of the top edges of the rafters and allowance must be made in the length of the jacks for the thickness of hip or valley rafter. In the case of the cripple jack this amount of reduction will be equal to ½ the diagonal thickness of the hip plus ½ the diagonal thickness of the valley, measured at right angles to the plumb cut, Fig. 61, or measured in the plane of the plate, or a parallel plane.

Top and bottom ends of cripples are alike, but in nailing them in place the lower ends must be held up so that their center lines will strike the center of the valley rafter. Their tops will be kept even with the outer arrises of the hip whether the hip is backed or not.

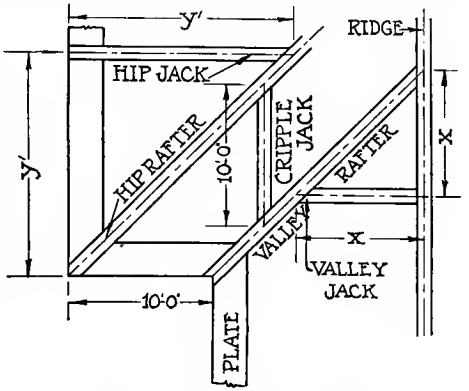


Fig. 66. Lengths of Jack Rafters.

In determining the true length of hip jack and valley jack we should know that a reduction of ½ the diagonal thickness of hip or valley, measured straight back from the plumb cut, is to be made. In the case of a valley jack resting against a ridge piece, an additional reduction must be made as described in Section 19, Fig. 56. In actual practice carpenters usually measure the length of hip or valley jack from the long point, along the arris, instead of along the center of the top edge, no reduction being made for ½ the diagonal thickness of hip or valley. Cripple jacks are measured from long point to long point, no reduction being made for thickness of hip and valley.

Second Method: Where jacks are framed so that equal spacings may be laid off, beginning with a full length common rafter, as in Fig. 67, the simplest method of determining lengths of jacks is to first count the number of spaces between jacks, which must be laid off on ridge or on plate, and divide the length of common rafter by this number. The result will be the common difference between lengths of jacks. The longest jack will be framed first by reducing the length of common rafter by the common difference. The next, by reducing the jack just framed by the common difference, etc. This method is applicable to roofs of any number of sides.

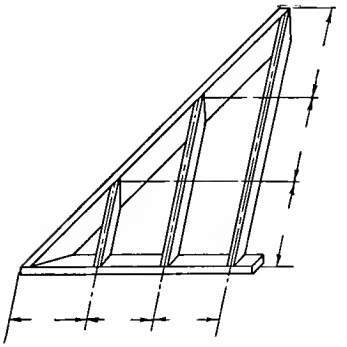


Fig. 67. Determining Length of Jack Rafters

Third Method: If we begin to frame with the shortest jack instead of the longest, we first determine the length of the shortest jack, remembering that its run in the square cornered building will be the same as its spacing from the corner along the plate, or along the ridge in case of a valley jack. The length of this first jack will also be the common difference, which will be added to each jack successively to get the length of the next.

Fourth Method: As rafters are usually spaced either 16″ or 24″ apart, a table consisting of the common differences in lengths for the various pitches will be found convenient, Fig. 49. The steel square of Fig. 50 also shows such a table for the square roof.

CHAPTER IV

Roof Frame: any Polygon

30. Tangents; Miter Cuts of the Plate.— Before the principles involved in the laying out of rafters on any type of roof can be understood, a clearer idea of the term tangent as used in roof framing must be had. A tangent of an angle of a right triangle is

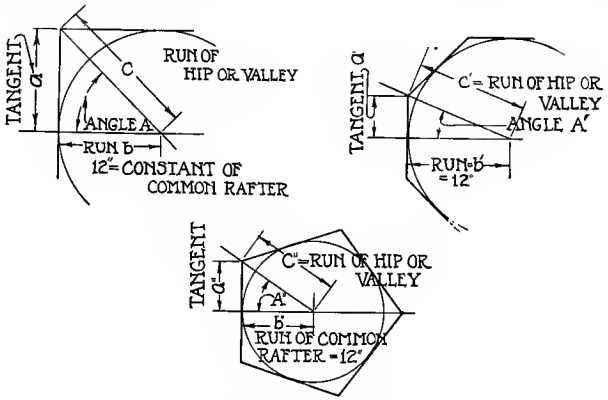


Fig. 68. Tangents

the ratio or fractional value obtained by dividing the value of the side opposite that angle by the value of the adjacent side. The tangent at the plate, to which reference was made is the tangent of the angle having for its adjacent sides the run of the common rafter and the run of the hip or valley. By making use of a circle with a radius of 12″ we may represent the value of this tangent graphically in terms of the constant of common rafter run, Fig. 68. By constructing these figures very carefully and measuring the line marked tangent, we may obtain the value of the tangent for

the polygon measured in inches to the foot of run of the common rafter. Such measurements, if made to the 1/100 of an inch will serve all practical purposes. A safer way, however, is to make use of values secured thru the trigonometric solutions described in Appendix I, using the graphic solutions as checks. The values of tangents at intervals of one degree are given in the Table of Natural

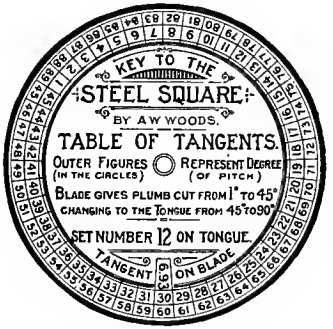

KEY TO THE
STEEL SQUARE
BY A W WOODS.
TABLE OF TANGENTS.
OUTER FIGURES (IN THE CIRCLES) REPRESENT DEGREE (OF PITCH)
BLADE GIVES PLUMB CUT FROM 1° TO 45°
CHANGING TO THE TONGUE FROM 45° TO 90°
SET NUMBER 12 ON TONGUE.
TANGENT
ON BLADE

Fig. 69-a. Table of Tangents

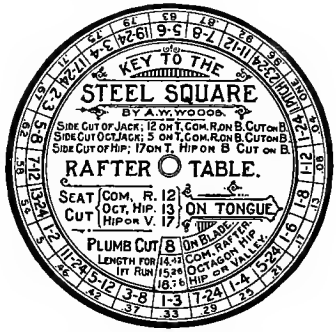


Fig. 69-b. Rafter Table.

Functions, Appendix II. By interpolation, fractional degree values may be found.

Example:

Find the value of the tangent for an octagonal plate.

Solution:

Angle A' of Fig. 68 = $22\frac{1}{2}°$

($\frac{1}{16}$ of the sum of all the angles about a point)

Tan $22\frac{1}{2}°$ = .4143

Tables are builded with 1 as a base. In roof framing 1′ or 12″ is taken as the constant or base, or unit of run of common rafter. .4143 may be considered as feet, which equals 4.97″.

In a similar manner tangents may be found for plates of buildings of any number of sides.

In Fig. 69 is illustrated a handy device one side of which, by the twirling of one disk within the other, can be made to give tangent values, in terms of a 12″ base, for any number of degrees. The

reverse side of this "key" gives data to be used in the framing of square cornered and octagonal roofs. Such a key will be found a convenient way in which to carry needed data and should be easily understood and intelligently used, once the principles discussed in this chapter are mastered. An explanation of the author's key, Fig. 70, will be found in Appendix IV.

Now as to some of the uses for tangent values: First, by taking 12″ on the tongue and the tangent value in inches per foot of common rafter run upon the blade of the square, we are able to get the lay-out for the miter joint of the plate.

Fig. 71-b illustrates the square placed for the lay-out of the octagonal plate or sill miter. Five inches is taken as tangent since the real value 4.97″ is equivalent to 5″ for all practical purposes.

For the square cornered building 12″ and 12″ would be used in making the plate miter lay-out, since the tangent of 45° is 1 according to the Table, Appendix II. Any other like numbers would give a tangent value of 1, of course, but it is best to consider 12″ on the tongue, in which case 12″ must be taken on the blade.

Second, this tangent value is needed in determining the cheek or side cut of hip, valley and jack rafters, as will be shown in Sec. 35.

Third, this tangent value is needed in determining the amount of backing to be given hip rafters. This is discussed in Sec. 39.

Not infrequently the plate miter in degrees is required. This is determined for any regular polygon by the proposition: The

$$\text{plate or miter angle of any regular polygon} = 90° - \frac{\text{central angle}}{2}$$

Example:

Find the value of the plate miter of the octagon.

Solution:

The octagon has 8 sides; therefore central angle = 45°

45° ÷ 2 = 22½°

90° — 22½° = 67½°

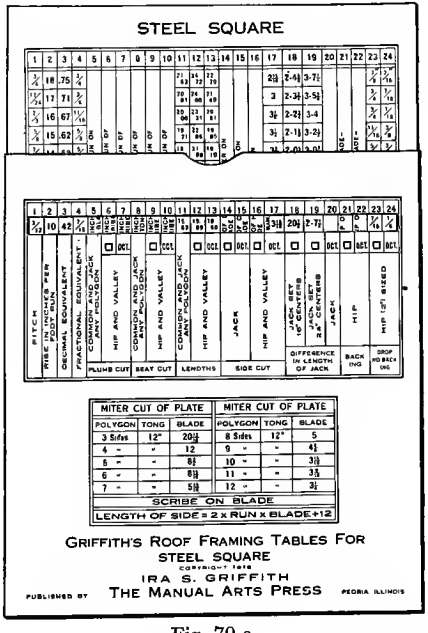


Fig. 70-a.

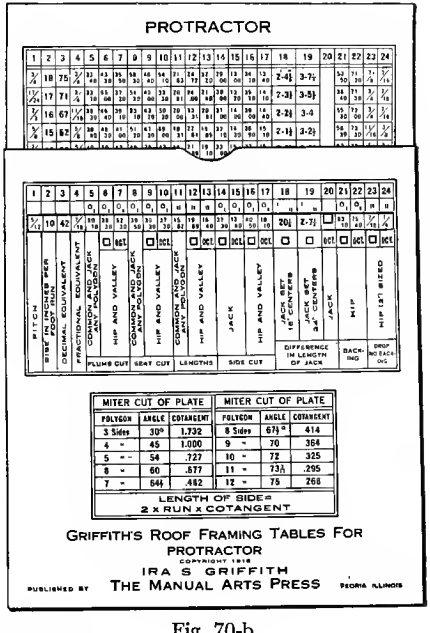


Fig. 70-b.

Griffith's Roof Framing Tables

Fourth, the tangent value is needed in finding the length of a side of a polygon, the span or run of the polygon being known, and vice versa. Length of side = span x tangent of plate, using 12″ as base.

Example:

An octagonal silo has a span of 18′; determine the length of plate for any side.

Solution:

The tangent value of the octagon = 4.97″ (to each 12″ of run) 18 × 4.97″ = 89.46″ = 7′ 5.46″ = 7′ 5½″.

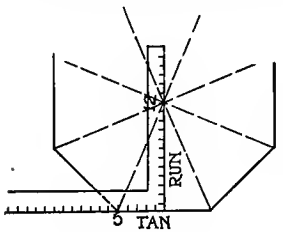


Fig. 71-a.

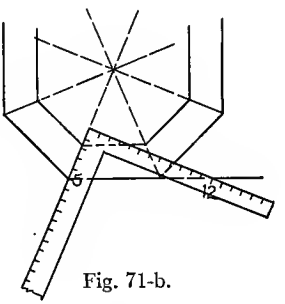


Fig. 71-b.

Laying out Miters

Example:

A side of a hexagon measures 4′; determine the run of the hexagon.

Solution:

Transposing the rule above: Span = length of side divided by tangent of plate.

Tangent of hexagon = 6.92″ when base = 12″

4′ divided by 6.92″ = 6′ 6.48″ = span. Run = 3′ 3.24″

31. Octagonal Roofs.— While the square cornered building is the most common, the octagon is frequently used in the form of a bay attached to the side of a house. The octagon is also common upon silos and towers. The manner of finding the run, tangent, length of hip and valley rafter, miter cut of plate or sill, the manner

of determining the numbers to use on the square to lay out the plumb and seat cuts, etc., will be found developed herein for both square and octagonal roof. Having mastered the principles involved in these two forms, the student should be able to work out framing problems for roofs of any number of sides.

32. Common Rafter for Plate of any Number of Sides.— By referring to Figs. 68 and 72 it will be seen that common rafters have for their runs the apothem of the polygon made by the plate, represented in Fig. 68 by the lines b, b', b''. The run of the hip is represented by the line c, c', c''. The rise will be found the same for full length common rafters and hips. Plumb and seat cuts and lengths per foot of run of common rafters and jacks are determined for a building of any number of sides just as for the square cornered building. The degree of inclination of common and jack rafter is applicable, too, Fig. 49.

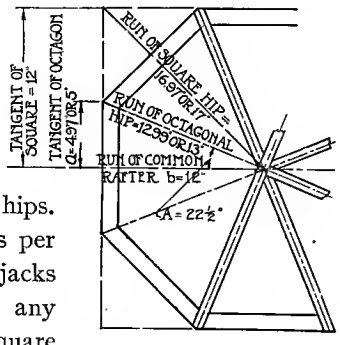

TANGENT OF SQUARE = 12"
TANGENT OF OCTAGON = 4.97 OR 5
RUN OF SQUARE HIP = 16.97 OR 17
RUN OF OCTAGONAL HIP = 12.99 OR 13
RUN OF COMMON RAFTER b=12"
A = 22½°

Fig. 72. Run of Common Rafter of any Roof is Apothem of Polygon

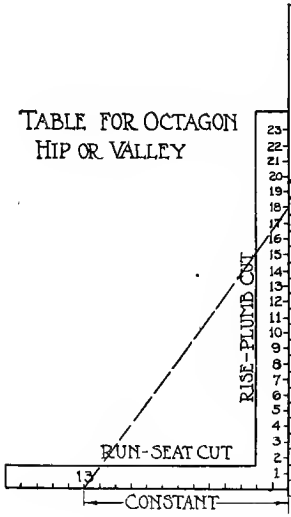
33. Hip and Valley Rafters for Octagonal and other Polygons. — Before the table of constants for hips and valleys for octagonal and other polygonal roofs can be formed, it is necessary to determine the tangent values of these polygons, as described in Sec. 30.

Proceeding with the octagon, whose tangent was found to be 4.97″ when the run of the common rafter was taken as 12″, by the formula $c^2=a^2+b^2$, Fig. 72, the run of the octagon hip or valley will be found to be 12.99″ for each foot of run of the common rafter.

34. Plumb Cut of Octagonal and other Polygonal Hips and Valleys.— The run of an octagonal hip or valley is 12.99″ for each foot of run of common rafter. For practical purposes this is con-

sidered as 13″. To lay off a plumb cut for an octagonal hip or valley, take 13″ on the tongue and the rise per foot of run of common rafter on the blade, Fig. 73; scribe on the blade.

In a similar manner, having determined the tangent of any polygon under consideration, the run of hip or valley per foot of



PITCH OF ROOF	PLUMB CUT (IN DEGREES)	SEAT CUT (IN DEGREES)	LENGTH OF HIP OR VALLEY PER FOOT OF RUN OF COMMON RAFTER	SIDE CUT OF HIP OR VALLEY	BACKING OF HIP IN DEGREES	AMOUNT OF DROP OF HIP NO BACKING
	° ′	° ′	INCHES	° ′	° ′	INCHES
3/4	35-50	54-10	22 20	13-40	71-20	7/16
17/24	37-30	52-30	21 40	14-10	71-30	7/16
2/3	38-10	50-50	20 61	14-20	72-00	7/16
5/8	41-0	49-0	19 85	15-10	72-30	3/8
7/12	42-50	47-10	19. 10	15-40	73-00	3/8
13/24	45-0	45-0	18.38	16-20	73-40	5/16
1/2	47-20	42-40	17 69	17-0	74-10	5/16
11/24	49-50	40-10	17.03	17-40	74-50	5/16
5/12	52-30	37-30	16-40	18-10	75-40	1/4
3/8	55-20	34-40	15 80	18-50	76-40	1/4
1/3	58-20	31-40	15 26	19-20	77-40	3/16
7/24	61-40	28-20	14 76	20-0	78-30	3/16
1/4	65-10	24-50	14 30	20-30	80-00	3/16
5/24	69-0	21-0	13 91	21-10	81-30	1/8
1/6	72-50	17-10	13 59	21-30	83-00	1/8
1/8	77-0	13-0	13 33	22-0	84-40	1/8
1/12	81-20	8-40	13 13	22-10	86-20	1/16
1/24	85-40	4-20	13 02	22-20		
			12 99	22-30		

Fig. 73. Table for Octagon Hip or Valley

run of common rafter may be figured. The result will give the number to take on the tongue when the rise per foot of run of common rafter is taken on the blade, for laying out plumb cuts.

35. Side or Cheek Cuts of Hip and Valley Rafters for Roofs of Any Number of Sides.— Fig. 74 illustrates the principles involved and method used in determining side cuts whatsoever the pitch and number of sides involved. (1) Lay the square across the jack or hip or valley, whatever is to be framed, at any convenient place, using on the blade the tangent (with 12″ as base) of the polygon

being framed, and on the tongue the constant of the run of the common rafter, 12″. Scribe along the tongue A–C, Fig. 74. (2) With the square, carry the line B–C across the edge as indicated. (3) Lay off the plumb cut for the required pitch, taking upon the blade the rise, and upon the tongue the constant of the run of the hip or valley or jack, according to the requirements for that par-

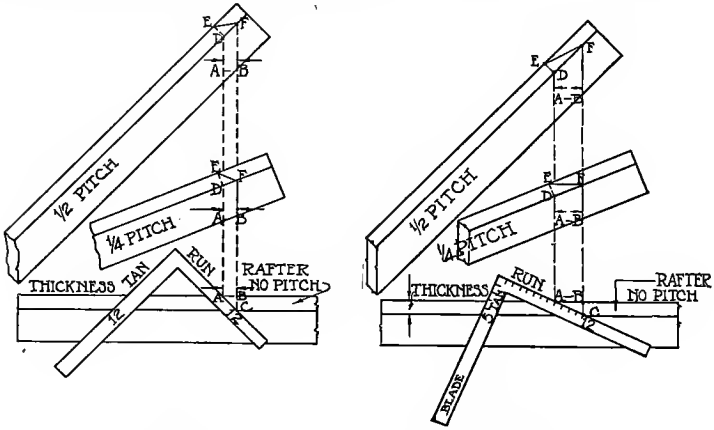


Fig. 74-a. Fig. 74-b.
Laying off Side Cut of Jack, Hip or Valley, any Polygon

ticular member as determined by the style of roof. (4) Measure square back from this plumb cut line the distance A–B of Fig. 74. (5) Thru point A scribe a line D–A parallel to that of the plumb cut line and (6) square this across the edge as at D–E. (7) Adjust the bevel to pass thru E and F, Fig. 74. (8) Scribe a plumb cut line upon the reverse surface of the stock.

It will be observed that in one case the square is laid across the edge with 12″ on the tongue and 12″ on the blade, Fig. 74-a. This, as might be supposed, is for finding the cheek or side cut for jack, hip, or valley on square cornered buildings where the tangent is 12″ when the run is 12″. In the case of the octagonal hip, valley,

or jack 5″ must be taken upon the blade, since that is the tangent value of the octagon, 12″ as base being taken on the tongue, Fig. 74-b. This tangent value will vary, then, according to the number of sides to the building.

The reason for using the tangent and run for this work is indicated by the position of the square on the plan of the roof, Fig. 75. These figures are for use only when the timbers lie in the plane

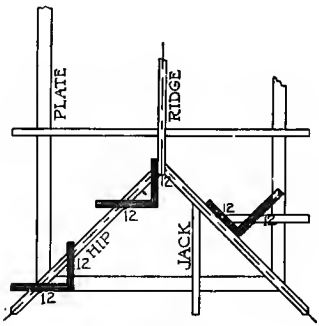


Fig. 75-a.

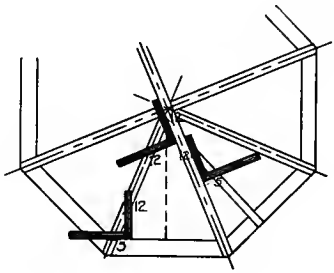


Fig. 75-b.

Securing Value of A–B of Fig. 74, Various Angles

of the plate, or any parallel plane. When rafters take on pitch or rise, however, the upward projection of the plan of the miter cut, Fig. 74, will determine the side cut as just described.

36. Rafter Lengths of Octagonal and other Polygonal Hips and Valleys.— *First Method:* Knowing the run of a hip or valley for the polygon under consideration (17″ for the square, 13″ for the octagon, etc.), by assuming the respective rises for the various pitches and solving $c'^2 = a'^2 + b'^2$, Fig. 76, data pertaining to hip or valley unit rafter lengths, such as that for the octagon in Fig. 73, is obtained.

To determine a rafter length, having available such a table, multiply the hip or valley length per foot of run of common rafter

as given in the table by the run of the common rafter of that roof. Reduce to feet. Such lengths will be laid off by measurement from the side or cheek cut, which will have been laid off, down the top edge of the rafter.

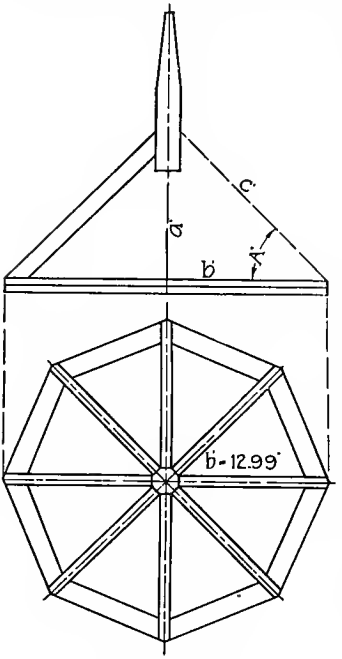


Fig. 76. King-Post

Lengths of hip or valley tails will be determined in a similar manner from the same table.

Second Method: This consists in successive placings of the square, using the same numbers on tongue and blade as will be used in laying out the plumb cut for this particular roof. The successive advances will be determined, as in the hip or valley of a square cornered building, by the number of feet in the run of the common rafter of this roof. A fractional part of a foot in run will be treated in a manner similar to that described for the square cornered building. Suitable allowance must be made for the fact that the length of rafter is along the middle of the top edge of the rafter, when this latter method is used.

Example:

An octagonal roof of ¼ pitch has a span of 25′.

The run of common rafter = 12′ 6″.

Taking 13″ on the tongue and 6″ on the blade lay off successively 12 measurements. Take $\frac{6}{12}$ or ½ of 13″ or 6½″ on the tongue and $\frac{6}{12}$ or ½ of 6″ or 3″ on the blade for the fractional foot of run.

37. Reductions in Lengths for King-Post. — Suitable reduction must be made for king-post, should there be one, Fig. 76, or for rafter thicknesses should no king-post be used, Fig. 75-b. Where a king-post is used the reduction will be ½ the width of the square out of which the king-post is formed, the measurement being made square back from the line of the plumb cut, as in reducing common rafter lengths for ridge piece, Fig. 56.

Where an apex is formed as in Fig. 75-b, one pair of hips is framed each with a run equal to ½ the octagon's diagonal, with cuts at the top the same as those of common rafters. The second pair will be similarly framed but the lengths will each be reduced an amount equal to ½ the thickness of the first pair, measuring straight back from the plumb cut. The third and fourth pairs will be reduced an amount equal to ½ the diagonal thickness of the rafters already framed, measured straight back from the plumb cut, Figs. 74-a and 75-b. These rafters will have to have double side cuts as indicated in Fig. 75-b. It will be noted that these latter rafters meet the others at an angle of 45 degrees, making the framing of the side cut similar to that of a square cornered building except that these are given double cheeks.

38. Seat and End Cut of Octagonal and other Polygonal Hips and Valleys.— The method of procedure in laying out the seat and end cuts of octagonal and other polygonal hips and valleys is similar to that described for the square hip, except of course, the numbers to use on the square will differ. These numbers will be determined by the run of the hip for that particular roof, and by the rise in inches per foot of run of common rafter. In the case of the octagon the numbers will be 13″ on the tongue, and the rise on the blade. The length of tail may be figured by the tables, if such are available, or the framing square may be advanced successively as many times as there are feet in the run of the tail or the lookout of the common rafter of that roof, as heretofore described.

The miter cut on the end of a hip rafter and in the crotch of a valley rafter will vary with the tangent value of the plate. For the octagon, whose tangent is 5″ the measurement from the end cut and at right angles to it will be $\frac{5}{12}$ that used on the square cornered building. This same ratio will hold for the measurement at the crotch of the valley, Fig. 65-b.

39. Backing Octagonal and other Hips.— The principle involved in determining the amount of backing on hip rafters for the octagon, as well as that of other polygons, is similar to that for backing hips for the square cornered building.

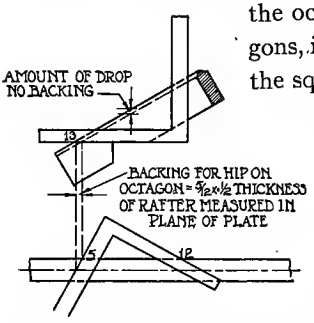


Fig. 77. Laying out Backing for Octagon Hip

(1) Place the framing square upon the hip as for making the seat cut of the octagon hip rafter, Fig. 77.

(2) Referring to Fig. 78 it will be seen that the more sides a roof possesses the less will be the backing required. Fig. 78 represents the hips on square, octagon, and hexagon as they would appear upon the plan if made to stand straight up at the corners of the plates. The backing in each case is determined by the tangent of the angle whose adjacent side is ½ the rafter thickness, and whose angle is equivalent to ½ the central angle as A, A', A'', Fig. 78. The fact that the hips are inclined and not vertical in their final position in a roof makes no difference in the principle of determining backing because of the fact that our measurements are made in a horizontal plane, or in the plane of the plate, Figs. 64 and 77.

The ratio of the backing of the octagon or any other polygonal hip to that of the square of equal rise will be proportional to their tangent values. For illustration, on the square roof we measured

along the tongue of the square, from the top edge of the hip, Fig. 64, ½ the thickness of the rafter, for reasons made plain in Fig. 78. In laying off the octagon backing we should lay off along the tongue in the line of the octagon seat cut, $1\frac{5}{12}$ of ½ the thickness of the rafter. In the case of a 2″ rafter, $1\frac{5}{12}$″ will be set off, using that side of the square containing graduations in 12ths.

(3) Where backing is not desired the rafter will be dropped a plumb distance equal to the plumb distance of the backing of the rafter, Fig. 77. Consult Fig. 73.

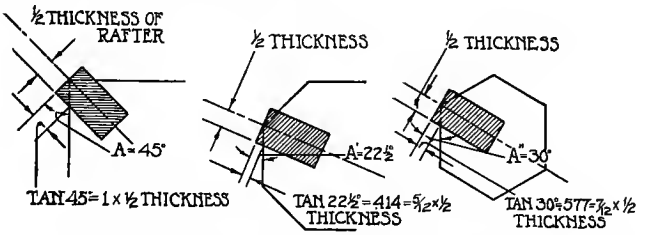


Fig. 78. Backing for Hip of any Polygon

40. Framing the Octagonal and other Polygonal Jacks.— Plumb cuts of jacks are determined by the rise and run of the common rafter of that particular roof. The seat cuts will be determined by the same numbers. Side cuts, end cuts, and lengths of jacks are determined as described in Sections 41 and 42.

41. Side Cut of Octagonal and other Polygonal Jacks.— *First Method:* The method described in Section 35 is applicable to jacks as well.

Second Method: If a table of common rafter lengths per foot of run is available, the side cut of any polygonal jack may be laid out by placing the framing square across the top of the rafter, taking the tangent value of the polygon on the tongue, and the length of common rafter per foot of run on the blade, and scribing on the blade. The tangent of the polygon forms the opposite side

of a triangle in which the adjacent side is the length of common or jack rafter per foot of run. The angle formed being the angle of side cut of jack.

42. Lengths of Octagonal and other Polygonal Jacks.— The methods of procedure in determining the lengths of jacks for other than square cornered buildings differs from that described for the square cornered building only in the fact that the runs, hence lengths, of the jacks must be determined differently. An examination of Figs. 68 and 72 will show that the runs, hence the lengths, of jacks for the square, the octagon, etc., when the run of common rafter is the same, will vary inversely as the tangent ratio. For example, the tangent of the square is 12″ when its run of common rafter is 12″, while that of the octagon is 4.97″ or practically 5″. The runs, and, therefore, the lengths of octagon jacks will differ one with reference to another, $\frac{1}{5}^2$ of those of the jacks for the square building. If an octagon jack rests 24″ from the corner, its run, and therefore its length, will be $\frac{1}{5}^2$ times that of a jack on a square cornered building similarly placed.

Second Method: Difference in lengths of jacks may be determined by counting the spacings along the plate and dividing the length of common rafter by that number.

43. Framing by Means of a Protractor.— By means of a protractor used in connection with the columns containing degree measurements, Figs. 49, 60, and 73, roof framing may be greatly simplified.

To lay off a seat cut, it is merely necessary to look in the table of hip, valley, jack, or common rafter, whatever is being framed, and read the degree of inclination of rafter for the pitch required. The blade of a T-bevel is set by means of the protractor to this angle; or a combination tool may be used, and the tool applied as in Fig. 79.

The plumb cut and seat cut are complementary. Since a pro-

tractor is made to read in either of two directions, the plumb cut setting may be got by adding to or subtracting from 90 degrees the angle of inclination of that rafter. With a combination tool, one setting of the tool serves to lay out both seat and plumb cut.

The degree of setting for a side or cheek cut, the gage setting for backing, and the amount of drop where no backing is used will be found under appropriate columns in the tables referred to above. The manner of applying the combination tool for laying out plumb

Fig. 79. Laying off Seat Cut with Framing Tool

Fig. 80. Laying off Plumb Cut with Framing Tool

cut, seat cut, side cut and end cut is indicated in Figs. 79, 80, 81 and 82. The manner of determining the data found in these tables is a matter of trigonometric solution, no more difficult than that already given, and omitted for lack of space. Such problems may well form a part of the pupil's work in mathematics.

For Example: Data for side cuts of jack, hip and valley for square and octagonal roofs will be found in Figs. 49, 60, and 73. In these tables will be found a column marked "Degree of side cut of hip or valley," also of jack. To secure the angle of side cut it is only necessary to solve by simple trigonometric formulae, the triangle $a\ b\ c$ and then $a'\ b'\ c'$ of Fig. 62. The angle A is the angle of inclination of hip or jack or valley, and will be found for each inch of rise in the tables; the manner of determining the same having been described. The side b is $A-B$ of Fig. 74, the value of which is also easily determined once the principles of Fig. 74 are

mastered. With this data the student may find the angle A' of Fig. 62 as given in the tables.

Rafter lengths are determined as previously described in connection with framing with the steel square.

44. Translating Framing Problems from Protractor to Framing Square and Vice Versa.— Frequently it is desirable to translate framing problems from degrees to numbers to be used upon the steel square, and vice versa. To change from degree framing to

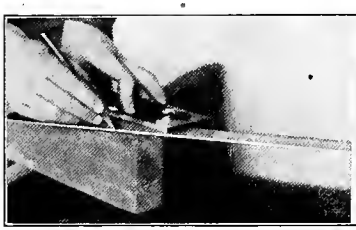


Fig. 81. Side Cut

Fig. 82. End Cut

steel square framing it is only necessary to remember that the numbers to use on the square must be numbers such that their ratio one to the other shall give a tangent value equal to that given in the Table of Natural Functions, Appendix II, for the angle under consideration. .

Example:

Given: Angle of inclination of common rafter or of roof = 30 degrees. Find the numbers to take on the square to frame seat and plumb cuts.

Solution:

Tan 30° = .577 (by Table, Appendix II).

By agreement, run of common rafter takes 12″ on one member of the square for constant of run.

Therefore, rise must be 6.93″, or $6\frac{11}{12}$″, must be taken on the other member of the square. (The base of the table is 1 so that for 12″ run we must have 12″ x .5774.)

In a similar manner the number to be taken on the blade, when the inclination of any other common or jack rafter is given, may be

determined. In the case of the hip or valley inclination, however, it must be remembered that 17″ is to be taken on the tongue for the run in the square cornered house, with 13″ in the octagon, which will necessitate multiplying the tangent value of the angle of inclination by 17 and 13 respectively to find the number to take on the blade when one or the other of these is taken on the tongue.

Example:

Given: Side cut of jack rafter, or hip or valley = 38 degrees.

Find the numbers to use on the framing square to lay off this same angle.

Solution:

Tan 38° = .7813

By agreement, we shall take 12″ on the tongue.

The number to be taken on the blade must be, therefore, 12″ x .7813 = 9⅜″

(In the case of the side cut, any number other than 12″ might have been assumed on the tongue.)

Example:

Given: A hip rafter on a square roof which is framed with 17″ on the tongue and 8″ on the blade.

To find the angle of inclination of the hip.

Solution:

$\frac{8}{17}$ = .4706

The angle whose tan = .4706 is 25° 19′

45. Framing an Octagon Bay.— Whatever may be one's opinion as to the propriety of the octagon bay architecturally, its very common use makes it obligatory upon the builder to know how to properly frame it.

Referring to Figs. 72 and 83-a it will be seen that the octagon bay is but a portion of a full octagon set up against the side of a house. From this it follows that the framing of the plate, sills, the laying out of plumb and seat cuts, and side or cheek cuts of jacks that rest against hips, etc., will be according to principles discussed in previous sections of the text. The chief thing which needs explanation is the matter of laying out side cuts for hips and jacks which are to rest against the side of the building.

Consider the bay as cut along the line *I–J*, Fig. 83-a. To frame the hip nearest the building: (1) Determine the angle which would give the side or cheek cut of the rafter involved when the rafter has no pitch, that is, when it lies in the plane of the plate. Fig. 83-a indicates the manner of determining this angle, which will be found to be 22½°. If we wish to use a framing square instead of a framing tool we may readily translate the 22½°. We shall find that 12″ taken on the tongue of the square will require 4.97″

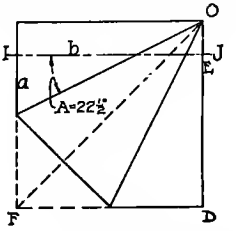


Fig. 83-a.

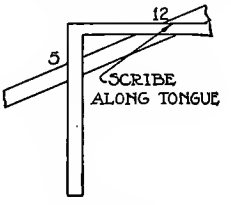


Fig. 83-b.

Framing Rafters of Octagon Bay

or 5″ on the blade. (2) Place the square as in Fig. 83-b and scribe along the tongue. Remember that this gives the miter when the rafter lies in the plane of the plate. This would give the cut to be used where ceiling joist or floor joist of octagon bay are run parallel with the rafters. On small bays, joists are seldom run thus but are run parallel with other joists of the house. No special directions are needed for setting the protractor, or the combination tool, the manner of setting and placing is so obvious. (3) Once having this miter when the rafter lies in the plane of the plate, proceed as directed in Sec. 35, (2) *et seq.* With one such rafter framed the mates may be laid out by transposition.

To frame the remaining hips of Fig. 83-a proceed in a manner similar to that just described. In this case the angle made by the hip when it lies in the plane of the plate and the side of the house will be 67½ degrees. Why? Fig. 84-a. The framing tool

or protractor and T-bevel provide the simplest means of framing. If one wishes to use the framing square he will find that by using the tangent value of 67½° he gets 28.97″ to take on the blade when 12″ is taken on the tongue. This he cannot find, of course. He may either take other smaller numbers having the same ratio, or he might better take the cotangent value of 67½°. Cot of an angle of a right triangle is the ratio of the adjacent side to the opposite side.

Solution:

Angle A' = 67½°, Fig. 84-*a*.
Cot 67½° = .414 when b' = 1.
When b' = 12″ cot A' = 4.97″ or 5″

(1) Place the square as in Fig. 84-b and scribe along the blade. By this time the student should have observed that the tangent value of any angle increases as the cotangent value of the angle decreases and vice versa. Note that when a cotangent value is used, 12″ is still taken on the tongue and the same number as for the tangent value of that number of degrees is taken on the blade, but that the scribing is done along the blade and not along the tongue as is the case when tangent values are used. (2) Proceed from this point as in Sec. 35, (2) *et seq.*

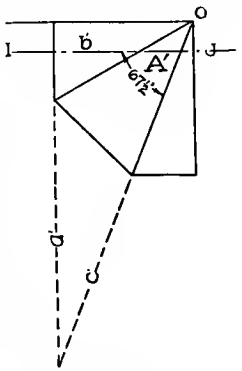


Fig. 84-a.

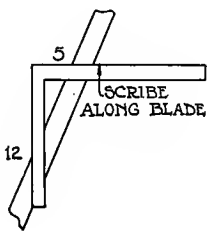


Fig. 84-b.

Framing Octagon Hip Intercepted at 67½°

To frame the jack intercepted by the side of the house. Fig. 85-a; (1) Proceed to find the miter for the intercepted jack when it

lies in the plane of the plate. It is 45 degrees. Tan 45 degrees = 1 when $b'' = 1$. Tan 45 degrees = 12″ when $b'' = 12''$. (2) Place the square as in Fig. 85-b and scribe along the tongue. (3) From this on, continue as in Sec. 35, (2) *et seq.*

From these solutions the student should be able to generalize sufficiently to care for rafters of any angle of intersection with the side of a building, and of any pitch. The use of the framing tool or protractor and T-square is strongly recommended upon

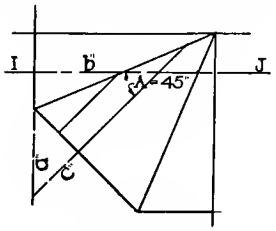


Fig. 85-a.

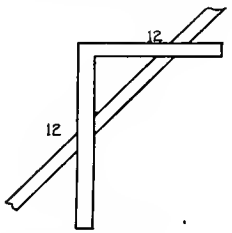


Fig. 85-b.

Framing an Intercepted Jack

such work as this. Nothing but tradition prevents its more general use in carpentry. Having determined the lay-out for the side cut of these rafters, the length of each must next be determined. To determine the length of hip or jack intercepted by the side of the house and the plate: (1) Determine the run of the intercepted part of the common or jack rafter, as *b*, Fig. 83-a. (2) By means of the table of rafter lengths per foot of run compute the length of rafter under consideration.

In determining the run of an intercepted part it is necessary to have data concerning the size of the octagon and the amount cut off by the building. The lines *E–D* and *F–D*, Fig. 83-a, when dimensioned, give this data. The actual lengths of the various hips, jacks, etc., in practical carpentry, upon small bays, are usually determined by actual measurement from the plate or sill to the proper point of intersection on the building as indicated by a

stick or extension rule held at the proper angle. Sometimes a large scale drawing is made and the runs taken from this. Upon large work where accuracy is necessary and measurements impossible, trigonometric solutions should be used.

To determine the length of the intercepted hip rafter over *c* of triangle *a b c* Fig. 83-a, the value of *b* must first be secured.

This value represents common rafter run for hip rafter rising over side *c*, and run of intercepted common rafter rising over side *b*.

Length of intercepted hip rising over side $c = b \times$ unit length of hip. (Table of lengths of octagon hips in terms of run of common rafter, Fig. 73.)

Length of intercepted common rafter or jack nearest house = $b \times$ unit length of common rafter. (Table of lengths of common rafter in terms of run of common rafter, Fig. 49.)

It must be remembered that these are theoretic lengths measured down the middle of the top edge of the rafters. In framing, suitable reductions must be made. For example, in framing the intercepted common rafter nearest the building, the rafter must be set over one-half its thickness that it may be nailed against the side of the building. The allowance necessary in order to do this may be secured by measuring the length from the long point instead of the middle of the side or cheek cut. Suitable reduction, too, must be made for the hip thickness — in this case one-half the diagonal across the top edge of the hip, laid off at an angle of $22\frac{1}{2}°$, or 5″ and 12″ on the square. This amount will be laid off straight back from the plumb cut, Sec. 35, (2) *et seq.*

Length of hip must be measured along the middle of the top of the rafter.

46. Framing a Roof of One Pitch to Another of Different Pitch.— Occasionally one must frame a roof of one pitch against a roof of another pitch. To determine the cut, if the combination tool is to be used, merely find the difference in degrees of the angles

of inclination of the two rafters, and apply the tool as indicated in the tables for making any other plumb cut, Figs. 49, 60 and 73. The seat cut will be determined by the rise and run of the shed rafter in the usual manner.

Where the framing square is to be used, lay the square as in framing a plumb cut on the shed rafter, as at *A*, Fig. 86, taking on the tongue, the run, and on the blade the rise of the shed rafter. Next lay a second square as at *B*, Fig. 86, taking on the blade the rise and on the tongue the run of the rafter of the main roof, using the blade of *A* as a reference edge. Blade of *B* gives the cut.

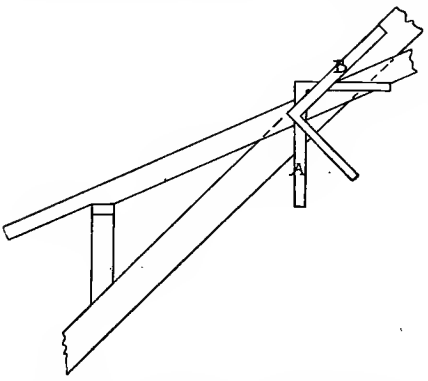


Fig. 86. Laying off Cut of Shed Rafter

47. Framing a Roof of Uneven Pitch.—Not infrequently a roof must be framed in which several pitches are involved. All of the principles necessary for framing such a roof have been developed. It remains for the student to make the applications to uneven pitches. It is advisable to prepare a framing plan as shown in Fig. 87. From such a plan it may be seen that the seat and plumb cuts of common and jack rafters are determined in the usual manner, being different upon the different pitches, of course, but determined as for any given pitch. Lengths of common rafters will be determined for any pitch by the tables already made use of, the run being known or determined.

In selecting the numbers to use on the tongue and the blade of the square, in laying out seat and plumb cuts of hip or valley rafters of intersecting roofs of different pitches, any numbers may be used

providing they have a ratio equal to that of the run and rise of the rafter being framed. Since the angle of intersection changes with every change of pitch, it is hardly worth while developing a constant to be used on the tongue in framing hip and valley rafters on irregular pitches.

Side or cheek cuts for valley, hip or jacks are determined according to principles developed in Sec. 35.

The backing of hips on roofs of uneven pitches, while the amount to be removed on each side of the hip will vary, is determined by the principles developed in Sec. 39. The amount to be removed from each side must be separately determined according to the angle the hip makes with the plate.

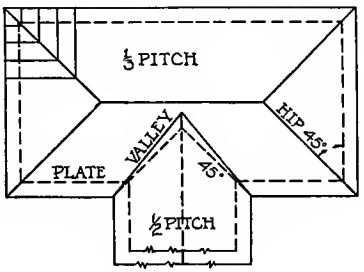


Fig. 87. Plan of Uneven Pitches

Lengths of hip and valley jacks are determined as in Sec. 42. Lengths of cripple jacks will not be of uniform length, as in even pitched roofs. The runs for such jacks may be obtained with sufficient accuracy by measurements taken from an accurately made scale drawing.

The following example will make clear the method of attack where it is desired to develop a constant for hip or valley in terms of the common rafter of one of the pitches.

Example:

Given: Main roof, Rise = 8′, Run = 12′ = $\frac{1}{3}$ pitch.
Minor roof, Rise = 5′, Run = 6′ = $\frac{5}{12}$ pitch.

(1) Find the run of valley rafter over *c*, Fig. 88-a, in terms of the run of the common rafter over *b*.

Solution:

$c^2 = a^2 + b^2 = (7\frac{1}{2})^2 + 6^2$. ($a : 12 :: 5 : 8$, whence $a = 7\frac{1}{2}$)

$c = 8.08'$

Expressing this run of valley in terms of 12″ of run of common rafter over b.

$8.08' : 6' :: x : 12''$

$x = 16.16''$. (Check this value by scale drawing.)

Length of valley rafter, then, is found by taking 16.16″ on the tongue with 10″ ($\frac{5}{6}$ of 12″) on the blade, advancing the setting as many times as there are feet in the run of the common rafter over b.

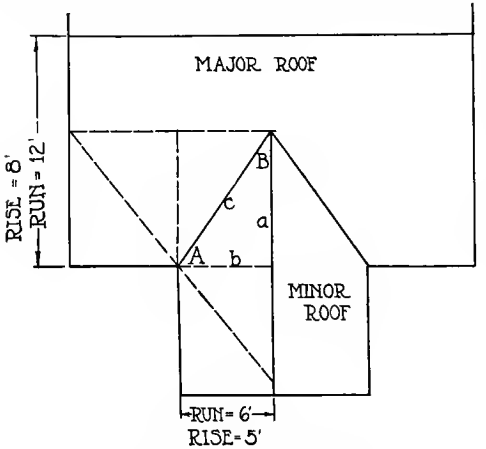


Fig. 88-a. Uneven Pitches

The numbers just given will give the plumb cut and the seat cut of this valley rafter.

(2) Find the side cut of the valley rafter when it rests against the ridge of the minor roof.

Solution: The side cut of the valley when allowed to rest in the plane of the plate = angle B, Fig. 88-a, whose tangent $= \frac{b}{a} = \frac{6}{7\frac{1}{2}} \left(= \frac{12}{15} = .800 = 38° 40' \right)$

Therefore, take 7½″ on the blade (always the run of intercepted common rafter of major roof), and 6″ on the tongue (always the run of the common rafter of the minor roof); scribe on the blade.

For side cut of valley rafter when it is to be fitted to a ridge of the major roof, the lay-out when in the plane of the plate is obtained by means of these same numbers, but the scribing is done on the tongue. This lay-out in either case is for the rafter when

lying in the plane of the plate. Having secured this, proceed as in Sec. 35, (2).

Side cuts of jacks for the minor roof are determined by the length of the ridge over *a*, Fig. 88-a, and the length of the rafter over *b*. But the length of the ridge over *a* = the run of the intercepted common rafter of the major roof, 7½′ here. A general rule may be derived, therefore: For the side cut of a jack on a minor roof take on the blade of the square the run of the intercepted common rafter of the major roof (inches for feet), and on the tongue

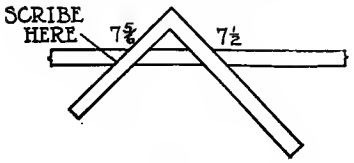


Fig. 88-b.

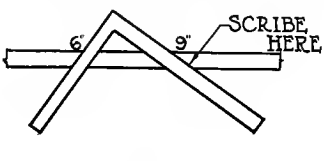


Fig. 88-c.

Side Cuts of Jacks for Uneven Pitches

take the length of rafter of the minor roof; scribe on the tongue, Fig. 88-b. For the side cut of jacks on a major roof, take on the tongue of the square the run of the common rafter of the minor roof, and on the blade the length of the intercepted common rafter of the major roof; scribe on the blade, Fig. 88-c.

A new problem arises in connection with uneven or irregular pitches, the problem of making the projecting cornice member one with another. Manifestly, if one part of a roof is steeper than another and the plate the same height all around the building, the cornice cannot be made to meet in the same plane. This difficulty is overcome by raising the plate of the steeper roof an amount equal to the difference in the rises of the two pitches for a run equal to that of the projecting cornice. For example, in a half-pitch the rise would be 24″ for a run of 24″ in the cornice. In a quarter-pitch rise for a 24″ run of cornice would be 12″, a difference in rises

of 12″. The plate of the steeper roof must be raised that much higher than that for the lower pitch.

48. Decks; Chimney Openings.— Decks are sometimes used in roof framing to prevent some part of the roof from rising too high above the remainder. Such decks are framed of joist stock spiked together with butt joints. Upon the top of such deck joists are placed feathering strips so sawed as to give the deck a slight "fall" in each direction, two to three inches in eight to ten feet. Upon these feathering strips flooring is laid.

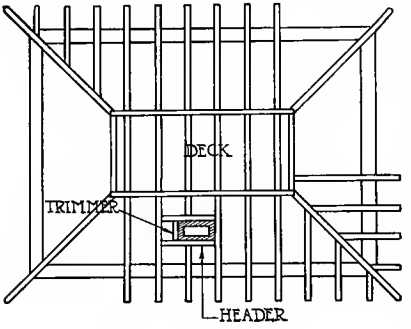


Fig. 89. Deck Frame

The deck is framed, raised and braced, being held up by studding placed under each corner. Next, the hip rafters are placed, then the flooring on the deck, and finally the common and jack rafters. Should common rafters be placed before the deck flooring, the joists must be braced to withstand the pressure against their sides. On large decks the outer deck frame is doubled.

Chimney openings are framed as shown in Fig. 89.

CHAPTER V

Exterior Covering and Finish

49. Sheathing or Sheeting.— After the frame work of a building is erected and the openings made in the frame for windows and doors, the sheeting is to be placed. Sheeting is placed either horizontally across the studs or diagonally, sometimes both ways, depending upon the specifications of the architect. The diagonal is somewhat stronger but is more expensive. The horizontal is satisfactory upon ordinary frame dwellings, especially where the building is braced at the corners by studs cut in diagonally, or by sheeting placed diagonally at the corners as in Fig. 90. Such sheeting should be matched and well nailed with two 8d nails to each stud. Building paper should be placed upon the sheeting to further protect the interior from cold.

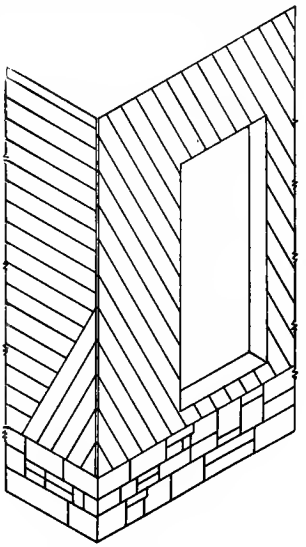


Fig. 90. Sheathing

Roof sheeting for shingle roofs may best be of unmatched boards spaced about 2″ apart. For slate, matched stock should be used and this covered with a tar or asphalt paper.

In making the face cut on roof boards for hips or valleys the framing tool or the T-bevel may be made use of, being set to the complement of the angle used in making the side or cheek cut

on jack rafters. The complement angle in this case equals 90° less the angle of the side cut of jack. Or, if the framing square is to be used, the same numbers used in making the side cut of the jack will be used in laying out the face cut of roof boards, with the scribing being done along the tongue instead of along the blade as in the case of the side cut.

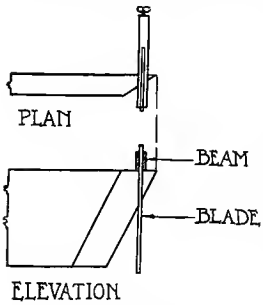


Fig. 91. Setting T-bevel for Roof Boards

A second T-bevel may be set as in Fig. 91, the beam being placed across the edge of the jack and at right angles to it, with the blade adjusted to the cheek or sawed surface of the jack which is to fit against hip or valley rafter. A framing tool might be used.

Carpenters more frequently, however, get the angles for sawing roof boards by laying the board to be cut out over the hip or valley rafter, then sawing along the side the rafter as in Fig. 92.

Fig. 92. Sawing Roof Boards

In warm climates, weather boarding is often applied directly to the studs, no sheeting being used; the frame being strongly braced at the corners.

50. Scaffolding.—Cornice is placed after sheeting. To do this advantageously it is necessary to erect scaffolding or staging. Fig. 93 illustrates a common type. Stock 2″x4″ is used for the uprights, and 1″x6″ for the horizontal members and braces or stays. Planks are placed upon

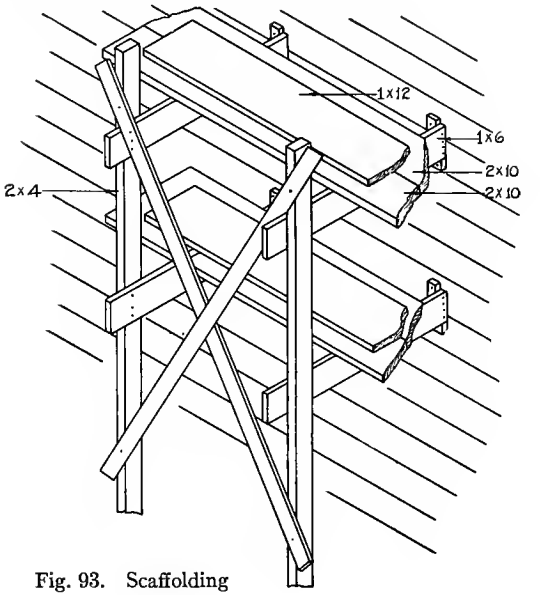


Fig. 93. Scaffolding

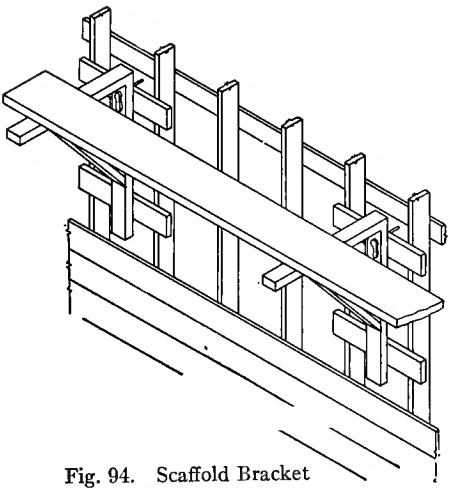


Fig. 94. Scaffold Bracket

these horizontals as shown. Fig. 94 illustrates a substitute for staging, a scaffold bracket upon which planks are laid.

51. Cornice.— Cornices are generally classified as open or skeleton, and box, Figs. 95 and 96. Each of these types will be found constructed in almost endless variety of forms. The illustrations shown will serve the purposes of this text. The student

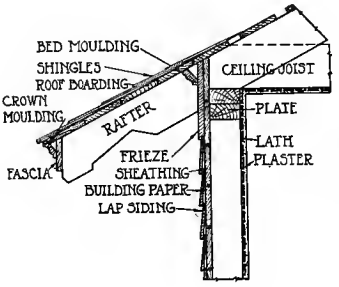


Fig. 95. Skeleton Cornice

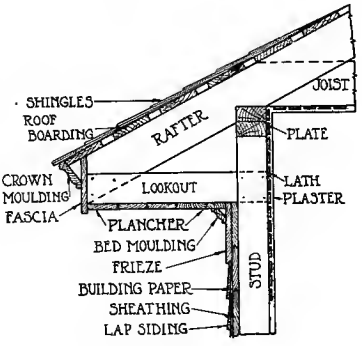


Fig. 96. Box Cornice

should familiarize himself with the various common forms, details of which may be got from any good, modern book on building details.

In making the various cuts on cornice work, a miter-box must be available for mouldings. The old type of wood miter box, with the various necessary cuts laid out in its sides is satisfactory. Some experimenting will be necessary upon the part of the beginner to determine the manner of placing the moulding in the box to give the correct cut.

The cuts for the plancher, which rests in the planes of a hipped roof and which must be membered around a corner are determined in a manner similar to that described for roof boards, Sec. 49, from the cuts of the jack rafter cheeks.

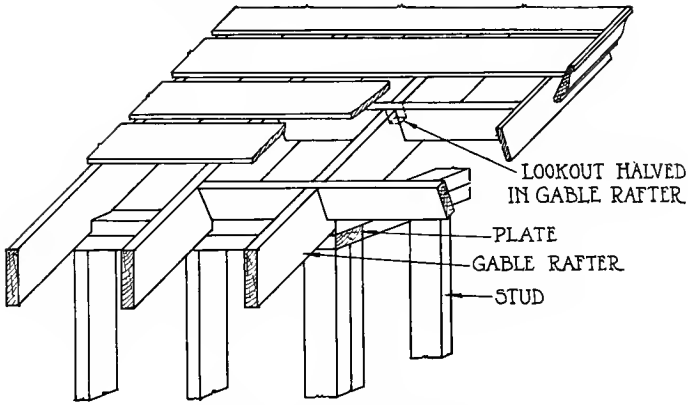


Fig. 97a. Skeleton Cornice

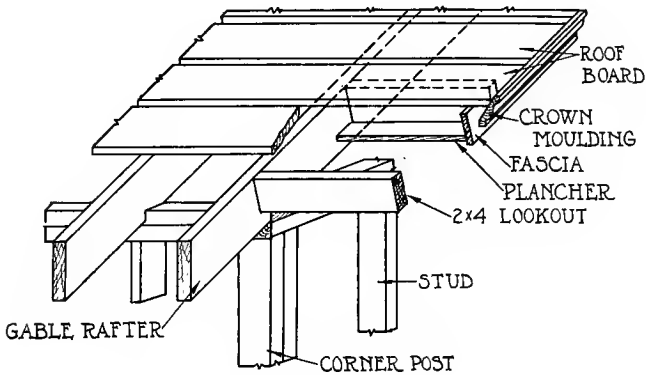


Fig. 97-b. Box Cornice.

Fig. 97 illustrates the manner of "framing in" the lookouts on gables where a skeleton cornice is used. Also there is illustrated the manner of placing lookouts in gables for a box cornice. Unless the cornice is quite wide, these blocks are merely fastened to the

underside of the roof boards at intervals of 3 or 4 feet. The depth of these blocks will depend upon the manner of framing the tail ends of the rafters.

Metallic gutters made to assume the form of the crown mould, no wood crown mould being used, will be found in common use upon ordinary house construction. A fall of ½ inch to every 10 feet is usually given gutters.

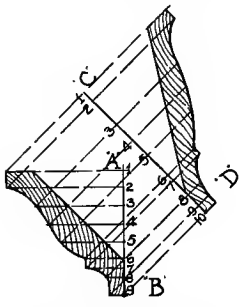


Fig. 98. Laying out Gable or Raked Moulding

52. Raked Mouldings.— In all cases where a moulding resting in one plane, as crown or bed moulding at the eaves, is to be membered with moulding swung up out of that plane, as up a gable, one of two things must be done to make the surfaces of the mouldings match or member properly at the joint: (1) The moulding at the eave may have its top edge tipped forward until its top edge lies in the same plane as the top edge of the corresponding gable moulding; (2) a moulding with a new face may be worked which will member with the eaves moulding when their reverse surfaces are fitted to the fascia or, in case of bed moulding, to the frieze.

To member by means of the second method proceed as follows: (1) Make a full sized drawing of a cross-section of the moulding, Fig. 98. (2) Draw a number of lines thru the more important reference points of the moulding at an angle equal to the pitch of the gable. (3) Draw horizontal lines thru the points of reference and erect a perpendicular thru these passing thru the back of the mould as *A–B*. (4) Lay off a line *C–D*, Fig. 98, perpendicular to the oblique lines. (5) Using the lines *A–B* and *C–D* as reference lines, transfer the distances of the various points on the eaves moulding, measured horizontally from *A–B*, to pitch lines meas-

ured obliquely. A curve traced thru these points will give the shape of the moulding required for the gable. Since this moulding would, in all probability, have to be worked up especially for any particular job, this practice is not followed except upon large or important work. Cornices are usually designed so as to avoid such work.

Figs. 99 and 100 illustrate two miter-boxes constructed for use in cutting rake mouldings in gables.

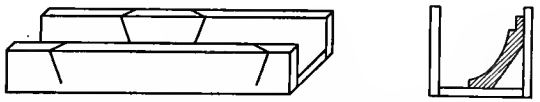


Fig. 99. Miter Box for Raked Gable Moulding Cut at Eaves

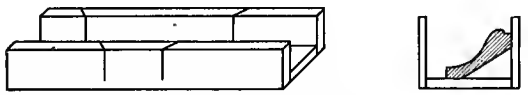


Fig. 100. Miter Box for Plumb Cut of Gable Mouldings

In making the miter cuts on mouldings of the eaves, the horizontal members, no special box is needed. The moulding will be set on the far side of the box, upside down. The box will have the side cuts perpendicular to the top edge and the angles across the top edges will be determined by the miter of the plate, sill, or corner of the building. On a square cornered building this miter will be one of 45°, 12″ and 12″ being taken on the square. Two cuts of each kind, but reversed, are made in each box so that the moulding for each side of each gable may be readily cut. On the octagonal building 5″ and 12″ would be used in laying out the miter, with scribing done along the 5″ member of the square.

For the miter cuts of the rake or gable member, special boxes would best be constructed. For the cut of the gable member

where it joins the eave moulding: (1) Lay off across the top of the miter-box, right and left, the miter of the plate, sill, or corner of the building. (2) Down the sides of the box lay off the slanting lines as shown in Fig. 99, at angles determined by the plumb cut of the common rafter. (3) Lay the moulding in the box as indicated by the cross-section, Fig. 99, being careful to keep the backs of the mouldings adjusted to the side and bottom of the box. A good plan is to drive a nail or two in the bottom of the box against which the moulding may be made to rest, once the proper position is determined by trial.

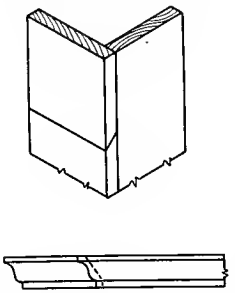


Fig. 101. Spliced Corner Boards and Moulding

For the plumb cut of the gable moulding, (1) lay off lines across the edges of the box as in Fig. 100, using on the framing square the numbers which give the plumb cut of the common rafter. Lay off a right and a left cut as shown. (2) Square these lines down the sides of the box and saw. (3) The moulding will be placed in the box as shown in the cross-section view of Fig. 100, especial care being taken to have the backs of the mouldings adjusted to the back of the box.

Manifestly, one box may contain all these cuts to advantage instead of having three boxes.

These cuts, Figs. 99 and 100, serve in cutting the miters on ends of the gable fascia. A little consideration will make clear the remaining cuts upon ordinary cornice work.

In splicing mouldings, corner boards, etc., a mitered joint is best and should be made so as to shed water from the joint, Fig. 101.

53. Shingling.— The reason for placing cornice before base or window frames, etc., is to allow the workmen to work inside should

inclement weather overtake building operations at any time. Shingling, therefore, will follow cornice work.

The amount of shingle to be exposed to the weather will depend in general upon the pitch of the roof. In no case should this exposure exceed 5 inches. The shingle most used is 16 inches long, and each shingle should lap two courses beneath it. The usual amount of lay is from 4″ to 4¾″, by quarters. When

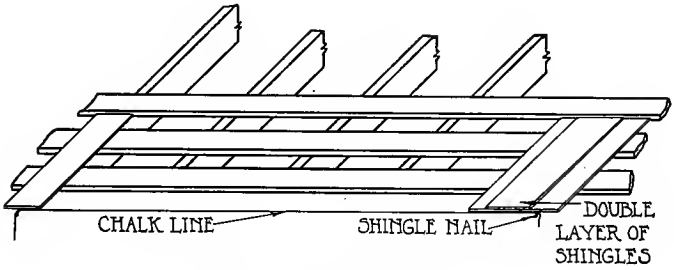


Fig. 102. Beginning Course

nearing the ridge or comb of a roof in shingling, the dimensions used on the main body of the roof should be increased or decreased so as to make the final layer show under the comb or ridge or saddle boards properly. The worker should begin such calculations when within about four or five feet of the ridge so that changes of exposure of the different layers may not be noticeable and so that the line of shingle butts may be kept parallel with the ridge.

The first layer of shingles should be a double one with joints properly broken, and with the butts projecting over the crown moulding about 1½″ to 2″. Lay the shingles at the gables first, then at intervals of about ten feet. Stretch a chalk line between these fastening it to the butts by shingle nails driven into the butts, Fig. 102.

The remaining courses may be laid by means of a straight-edge or by means of a chalk line. Both practices have ardent advocates. Where a straight-edge is used, it is usually a piece of lap siding or clapboard, and is held in place by being lightly tacked.

In using the chalk line a man for each end is required. The line is chalked and snapped for three courses at a time. The me-

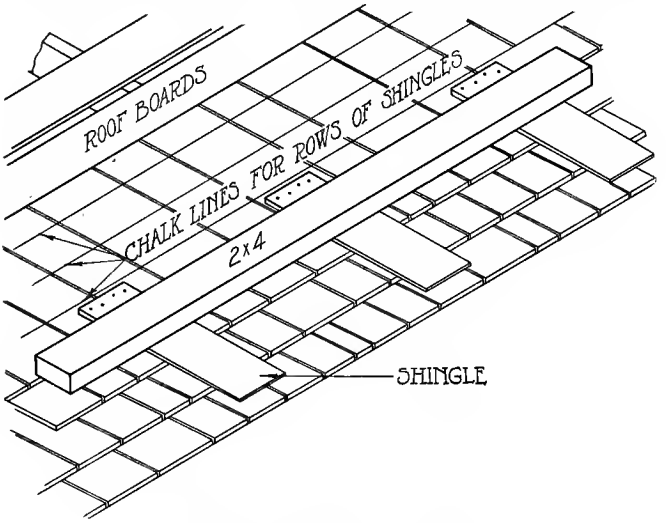


Fig. 103. Shingling. Toe Hold

chanic, after a little practice, is able to keep the butts of the shingles straight and to sight them so that they shall follow the chalk line mark. On long courses a third person may be utilized in chalking and in laying shingles. In chalking, this person holds the line to the roof as sighted by an end man and the snapping is done on each half of the line.

The chalking of a line so as to conserve the chalk is one of the tricks of the trade which must be mastered early. It consists in

rotating the chalk about its hemispherical axis while being worked backward and forward along the line, the line being held between the chalk and the ball of the thumb. Otherwise the line would soon sever the chalk.

Cut nails should be used in preference to wire nails because of their greater rust-resisting quality. Dry shingles should not be laid tight together, $\frac{1}{8}$ inch between is not unusual with dry shingles.

Fig. 104. Shingling. Toe Holds

It is best to split shingles over 10 inches wide before laying them. Each shingle should have at least two nails, the average is two nails for every four to six inches of shingle.

Scaffolding for roof work, or toe hold, is usually constructed by nailing shingles to 2″ x 4″ as shown in Figs. 103 and 104. Other forms are equally common. Apparently the holes left by the nails used to fasten the toe hold to the roof would cause a leak in the roof. To avoid any such danger, tho such danger is slight because of the swelling of the wood fiber upon the application of moisture, the shingles having such holes are driven down the roof slightly by striking their surfaces a glancing stroke.

54. Shingling Hips and Valleys; Flashing; Saddle or Comb Boards.— Hip and valley shingles are usually sawed to shape before

being taken to the roof, the face cut being the same as that used across the face of the roof boards and plancher members intersecting about a corner of a hipped roof where plancher lies in the plane of the roof. The cut across the edge of such shingles is made square to the face.

Of the many ways of protecting the intersection of hip shingles when in place upon a roof, the simplest is that of employing tin

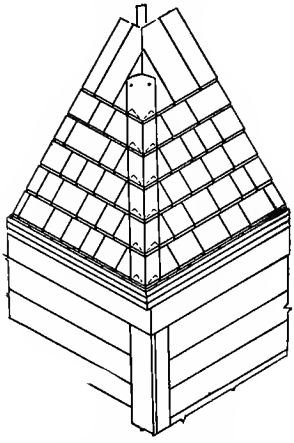


Fig. 105. Shingle Tins

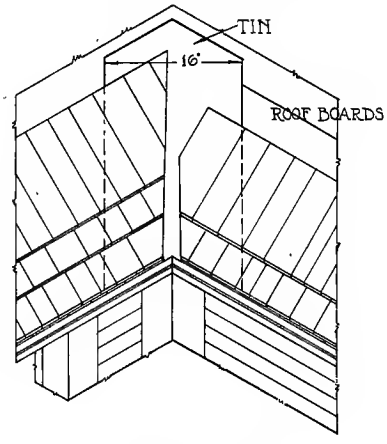


Fig. 106. Valley

shingles. Such shingles should be of sufficient length to allow the corners to be turned under as shown in Fig. 105, and still extend far enough under the next course of shingles to permit the nails holding the tins to be covered. It is not good practice to nail thru these tins after the roof has been covered, that is, to place these tins after the roof has been shingled because the action of the weather "lifts" the nails when exposed thus.

Valleys are covered with a strip of metal to a width of 20 inches. Upon steep roofs and short valleys this width may be reduced to

16 inches. Space must be left between the edges of valley shingles as shown in Figs. 106 and 107. The amount will depend upon the length of the valley and the steepness of the roof. For a ⅓ pitch with a length of twelve to fourteen feet of valley, the space at the top of the valley may well be 1 inch to each side of the valley center line, widening gradually toward the lower end to 2½ inches to each side. Chalk lines snapped upon the tin or other metal forming the valley indicate the location of shingle edges. Nails in val-

Fig. 107. Shingling Valley

ley shingles should be kept well back from the valley edge of the shingles.

Flashing consists in placing tin shingles or other material about the members making up a joint so that the joint shall "turn water." Counterflashing consists in placing a double layer of tins in such a way as to doubly insure turning water from a joint.

Fig. 108 is an illustration of flashing where shingles meet lap siding. Shingle tins are forced under the siding on one side and either under or over the shingles, several inches of lap being allowed all about.

Fig. 109 illustrates a counterflashed chimney. A layer of tins is placed as in flashing against siding except their top edges are not

inserted. Over these tins a second layer is placed as shown, the top edges being inserted $\frac{3}{4}''$ between the layers of brick, the mortar being raked out so that this can be done. These turned edges are held in place by the insertion of a wedging nail or tack, after which the cracks are filled with cement, or better, an elastic roofing composition.

Tins should be carried high enough to prevent drifted snow from entering; $2\frac{1}{2}$ or 3 inches at the narrowest place.

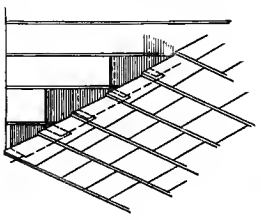


Fig. 108. Flashing

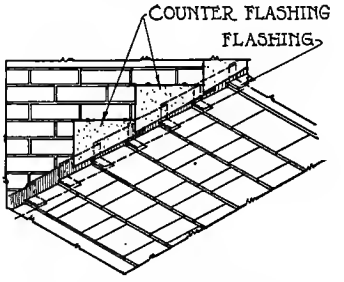


Fig. 109. Flashed and Counter-flashed

Saddle or comb boards are of various forms. They are used to give the ridge a finished appearance and to turn any water which might happen to strike thereon; also to hold the last course of shingles in place. A simple form is obtained by creasing to the appropriate angle a strip of tin eight inches in width. Place this on the ridge and nail its edges at intervals of 3 or 4 inches. Where boards are used, one board should overlap the other and extend a half inch beyond to turn water from the joint so made. Galvanized ridge rolls may be purchased in stock styles.

55. Finishing Exterior Walls.— With the roof completed, side walls are next covered except where porches are to be attached.

Fig. 110 illustrates the manner of constructing an exterior wall having a water table and lap siding, also the relation of the various parts of an exterior wall.

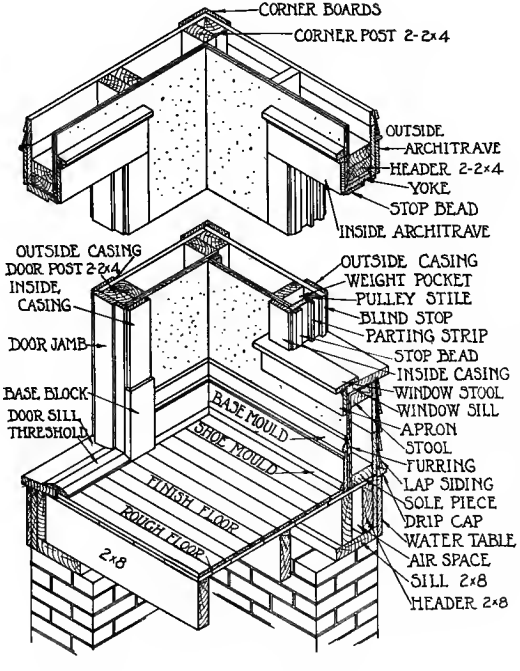


Fig. 110-a. Interior Wall Detail

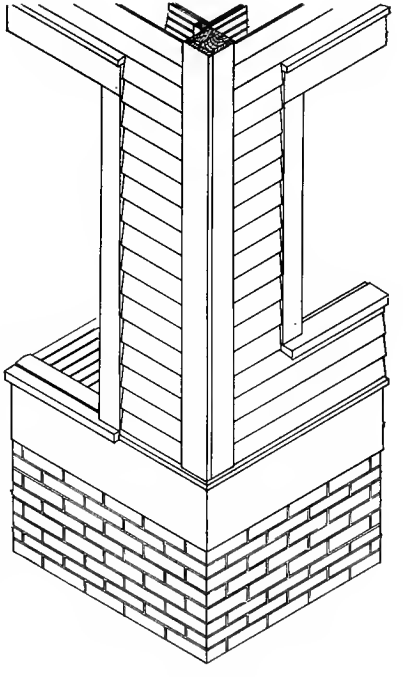


Fig. 110-b. Exterior Wall Detail

A belt course is sometimes used between the first and second stories of a building. Such a course is often constructed like the water table. Like the water table or base, this belt course is furred out in order to throw the course into greater relief. In case this furring is not done, the lower edge of the belt board must be rabbeted to receive the top edge of the siding. Frieze boards, too, are frequently furred instead of being rabbeted. More elaborate belt courses are common.

Fig. 111. Leveling Door Sill

Building paper should be stripped about the openings for doors and windows before the frames are set, to insure warmth; also about corner boards and cornice.

Corner boards and casing edges should be very slightly beveled so that the siding may take a slight squeeze as it is placed. Care in setting frames and in making casing edges true will insure a saving of time in placing siding.

56. Setting Window and Door Frames.— Two men usually work together in setting frames, as in fact they do on much other carpentry work. In setting door frames on outer walls (1) the rough floor, etc., must be cut away so that the top of the sill may rest on a level with finished floor when that is in place. (2) When this is done the door sill is carefully leveled, Fig. 111, and shingle points inserted under the sill where needed to give solidity and support. (3) The casing is given a nail close to the sill at each side of the frame and (4) the sides of the jambs are plumbed and the casings finish nailed. If the work is carefully done the frame should be square.

Where heads of several windows are a given distance from the floor, a stiff stick may be cut this length and used in placing windows in position for height. The window sills will be leveled as are door sills; the jambs are plumbed, Fig. 112, and casings nailed at intervals of about a foot.

57. Siding.— Preparatory to siding, a siding stick should be made. Such a stick is made by planing parallel edges upon a

Fig. 112. Plumbing Frame

Fig. 113. Using Siding Stick

piece of $\frac{7}{8}$ inch stock about 1 inch in width. Upon this stick marks will be made which will indicate the spacing of the siding; these marks being transferred to corner boards and casing edges, Fig. 113. To lay off this stick a given space is taken, water table drip cap to the lower edge of a window sill for example. (1) This space may be transcribed upon the stick easiest by setting the stick upon the drip cap and against the casing edge, marking under the sill upon the stick. (2) This space is "stepped off" by means of a pair of dividers set to the amount of exposure desired. Exposures will run from $4\frac{1}{4}$ to $4\frac{3}{4}$ inches on ordinary lap or bevel siding.

(3) Should there be a remainder, and there almost always is, the exposure must be increased or decreased, whichever is necessary, an amount sufficient to give an equal or even number of divisions. In practice this amount is found by stepping off as suggested and then making necessary adjustments by guess and again stepping. This is continued until the desired result is attained. The difference is thus divided equally over the whole space instead of over

Fig. 114. Marking Length of Siding

Fig. 115. Using Siding Hook

the last courses as in shingling. In a similar manner a stick, or another space of the same stick is laid off and stepped for the space between the bottom of the window sill and the top of the drip cap above the head casing of the window, etc. On long lateral spaces this stick will be used to keep the lower edges of the boards in position between the casings, by transferring its marks to the building paper, stepping down from one of these marks with a pair of dividers to the lower edge of the siding board being placed. (4) A bunch of siding boards should have one end of each sawed square across the face, but sawed under on the back side slightly so as to

insure a fit on the surface. (5) One end is next fitted, with block plane if necessary, after which (6) the length is marked by turning the board upside down and marking on the lower edge of the board, which is uppermost, with a knife, Fig. 114. Another way to mark length is indicated in Fig. 115. This tool is called a siding hook or tool and this method possesses the advantage of caring for any lack of squareness in the frame or trim.

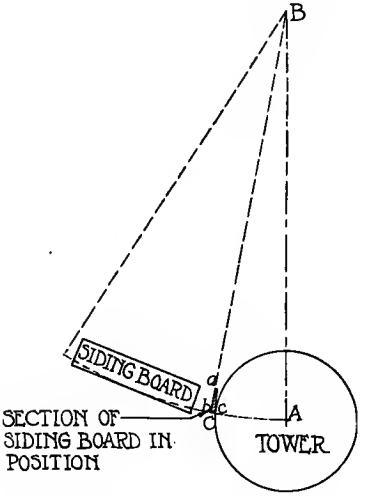


Fig. 116. Siding Circular Tower

In nailing, care must be taken to place the nail so that it shall pass thru both boards where lapped. Under windows it will be necessary to trim off part of the upper edges of the siding boards. Saw kerfs at either side of the part to be cut, and a sharp, deep knife scoring along a straight-edge should be used to outline the part to be removed. To determine the amount to be removed, set the dividers to the amount of spacing used for the boards in the space under the window, plus the depth of rabbet, or groove in the under side of the window sill into which the upper edge of the siding board must fit. Set off this amount on the siding board from the butt or under edge at each end of proposed cut, and connect with straight-edge; scoring with knife.

Occasionally the carpenter is called upon to side a circular tower or rounded corner of a building. That the lower edge of each board may rest in a horizontal plane it will be necessary to shape that edge before applying the board to the side of the building. To

determine the amount of curvature to give such an edge proceed as follows: (1) Plot a curve to represent the plan of the tower, Fig. 116. Draw this upon a scale sufficiently large and make use of accuracy such as will insure a result equal to the requirements of the occasion. (2) Draw the line *A–B* of indefinite length. (3) Place a section of a clapboard in the position it will have on the sheeting, as at *abc*, Fig. 116, and (4) extend a line along the face surface to meet *A–B*. (5) With a radius equal to *B–C* describe an arc with *B* as a center which shall cut the siding board as shown, taking an equal amount off the edge at each end.

Occasionally it becomes necessary to fit a casing against a sided wall. This casing is scribed as indicated in Fig. 117, a pair of sharp dividers being made to follow the contour of the wall with one point while the other marks or scribes the casing. A saw will be used to cut to these lines, sawing under slightly to insure a fit at the face.

Fig. 117. Scribing against Irregular Surface

CHAPTER VI

Interior Finish

58. Lathing; Grounds.— Lathing is usually considered a part of the plasterer's work but the carpenter is expected to prepare the grounds and place the necessary furrings. The success of the plasterer depends in no small degree upon the way the carpenter does this work. If corners are not firmly constructed, cracks will be sure to appear in the plastering.

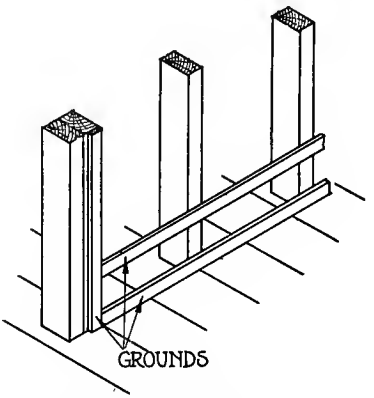


Fig. 118. Plaster Grounds

In lathing, joints must be broken upon different studding every dozen lath, and joints are not to be allowed about a door or window opening where their presence would weaken the wall; such as short lath nailed at one end only. Neither are lath to be placed at right angles to the usual run of lath on the wall because uneven shrinkage would cause the plaster to crack.

That the plasterer may make walls true and of uniform thickness about door and window openings and along the floor, grounds are placed as in Fig. 118. Such grounds are of stock $\frac{13}{16}''$ x 1″ or 2″ nailed firmly to the studding. Grounds for base should be placed so that the wall may be lathed and plastered entirely to the floor that cold and vermin may be kept out.

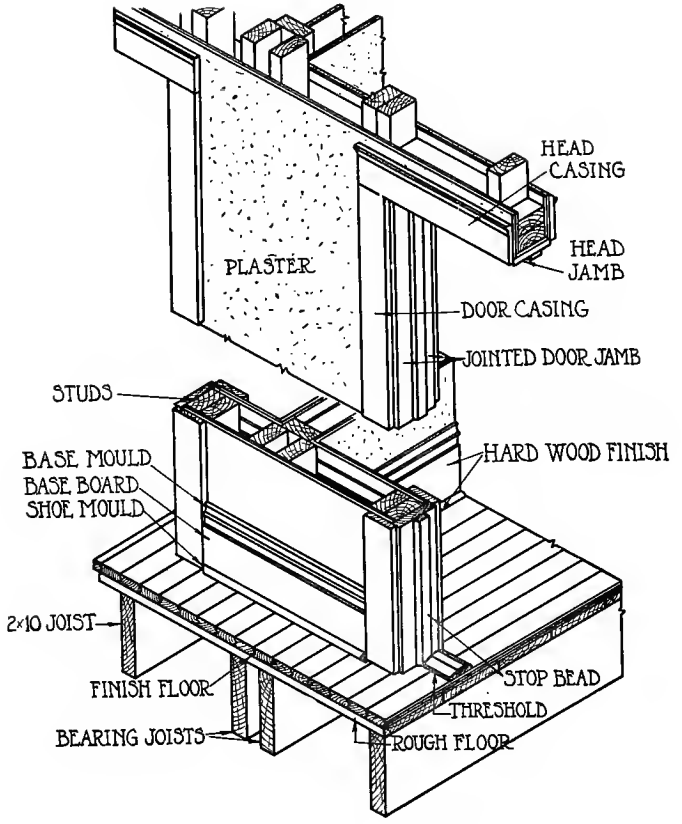


Fig. 119. Detail of Partition Wall

For grounds on external corners in a room, metallic corners especially manufactured for this purpose are recommended.

The beginner will be surprised at the numberless places requiring attention in preparing for the plasterer. He should visualize every corner and angle as he thinks the plasterer or lather must have it.

59. Interior Walls.— Fig. 119 illustrates the construction of a corner of an interior wall which is to be recommended highly for strength. All door studding are to be doubled for strength, also window openings of unusual size.

Interior door jambs are not usually placed until after plastering has been done. Thresholds are no longer used with interior openings where both rooms are to be heated.

Joists doubled to support partitions should be spread sufficiently to allow furnace pipes to enter, and still provide bearing for partition studs.

Badly crooked studs in a partition wall may be straightened by sawing a kerf on the hollow side, almost thru, and wedging with a shingle point. A cleat nailed to the side of the stud after wedging will give the original strength. Straight studs should be selected for use about openings.

In setting studs for interior door jambs where studs are to be doubled on the inside, add to the width of door enough to make the outer edges of the casings center on studs, and double inside these, as in figuring openings between studs for outside door jambs. Make allowance for the extra thickness of stud on each side. For height of opening, where no threshold is to be used, add $2\frac{1}{2}''$ to the height of the door. Remember that enough more must be cut from vertical studs to allow for thickness of header.

60. Stair Building; Porch Steps.— Stair building is an art in itself and as such belongs to millwork rather than to carpentry. However, the carpenter must know the principles of simple stair lay-out and construction for he is called upon to construct porch steps, basement and often attic stairs. In smaller communities he may also have to build the main stair. Fig. 120 illustrates three common types of stair.

In planning a stair, the first requisite is to know its rise and run, Fig. 121. The rise in this case is the vertical distance measured

Fig. 120-a-b

Fig. 120-c

Types of Stairs

from the top of the first floor to the top of the second floor. The run is the horizontal span of the stair.

A good average stair for a cottage will have a rise per step of 7 inches and a run of tread of 10 inches. Variations will have to be made in both rise and tread to meet conditions, but the student

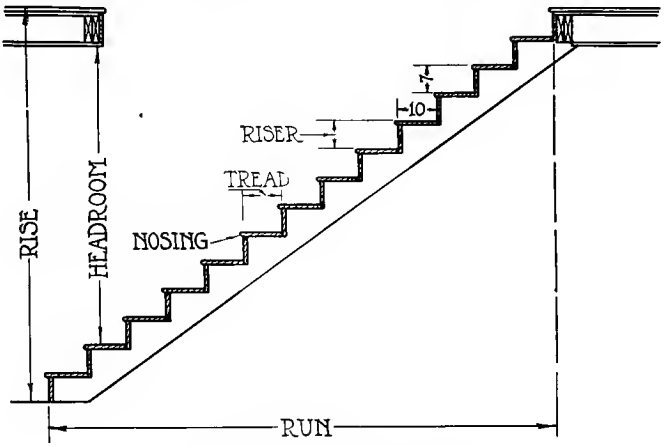


Fig. 121. Rise and Run of Stair

may take these dimensions as starting dimensions unless otherwise directed. Steps should not be either too steep, due to excessive rise per foot, or "slow" due to extreme width of step. An old rule for determining the relation of rise to tread is: "Twice the rise plus the tread should equal 24″."

Proceed as follows: (1) Lay off on a story pole the total rise of the stair by placing the pole upright in the well hole. (2) Set a pair of dividers to 7″ and step off this distance so marked. If there is a remainder, increase or diminish the divider's space and again step off the space. Continue this until a setting is obtained which gives no remainder. The number of risers will be found by counting the spaces, and the rise per step by measuring one of these

spaces. (3) If the run of the stair is not of exact specification (some variation is usually possible) the run per step or tread may be determined by the rule just given. If a definite total run is specified the tread must be figured. (4) Since there is always one more riser than tread, the run per step is obtained by dividing the total run in inches by the number of risers less one. The numbers thus obtained for rise and run per step are the ones to be used on the framing square in laying out the stringers.

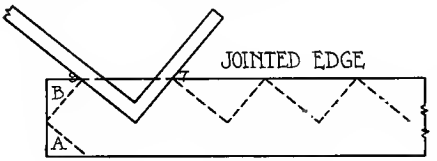


Fig. 122. Laying out String

(5) Joint one edge of each stringer straight and square and

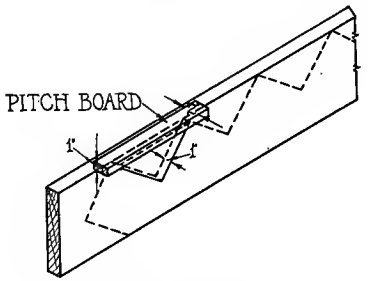


Fig. 123. Pitch Board.

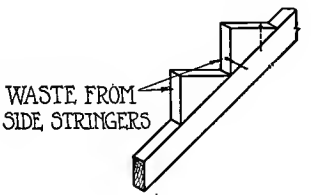


Fig. 124. Economical Center Stringer

place the framing square as in Fig. 122 and scribe along both blade and tongue. (6) Scribe the line *A* parallel to the 9″ run, at a distance from it equal to the rise diminished by the thickness of the proposed tread. (7) Continue to lay the square as in (5) until the required number of steps have been laid out. A pitch board might have been constructed and made use of instead of the framing square in laying out the stringers. This is nothing more than a piece of stock which serves as a template by which to lay out the

rise and run of each step, Fig. 123. A cleat or fence nailed to one edge after the three edges have been planed to dimensions permits easy and accurate placing of the same.

(8) There remains the sawing out. On open stringers this is done by sawing square across the board or plank. Where the exposed ends of risers would make a bad appearance, the cuts in the stringers for risers are made mitering and the ends of the risers are mitered correspondingly. In either case the end of the riser will be flush with the exposed side of the stringer or string.

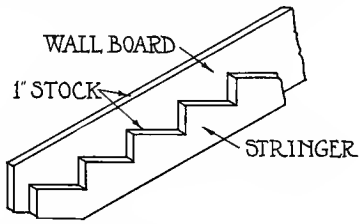


Fig. 125. Stringer for Attic Stair

Fig. 124 illustrates an economical way of constructing a center stringer, a 2″x 4″ having nailed to its top edge the waste cut from the side or wall stringers.

61. Risers and Treads.— Upon the common stair, such as attic and porch, etc., treads and risers are placed as in Fig. 120, being nailed to place, risers first and then treads.

On porch steps and open stringers, the treads should overhang at their ends an amount equal to that given the front. The cove, if one be used, should be carried around and "returned" under the end of the tread.

On enclosed or semi-enclosed stringers, a combination of stringer and wall board is commonly used. Fig. 125 illustrates a type of construction often used upon attic stairs. In this the side stringers are framed of 1″ stock and then nailed to the wall board of similar thickness. Such construction is not suited for first floor stair work where the effects of shrinkage would show to greater disadvantage.

Fig. 126 illustrates the manner of framing a modern stair suit-

able for a first floor where the best type of construction is demanded. As a rule, such stair work will be done at a mill and the stair brought to the building knock-down. The carpenter will have framed the rough stringers which are to support the ceiling below the stair, and placed them so that they may be used as a temporary stair for the workmen. If the stairway is an open one or semi-

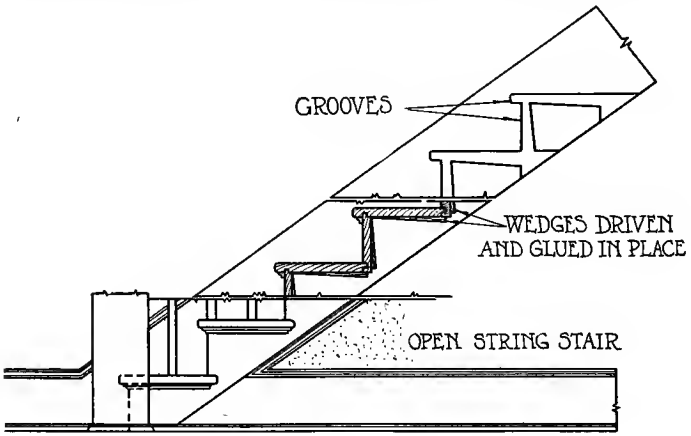


Fig. 126. Main Stair Detail

open, the plastering under these stringers will have been placed, the stair being put together on the floor and then raised to its place. If the well-hole is such that the stair must be assembled while the strings or wall boards are in place, the lath and plaster must be left off the rough stringers until after the stair has been assembled and the wedges glued and driven in place as shown in the illustration. Rough stringers must be placed far enough from the sides of the well-hole so that the wall board may settle in place and that the wedges may be easily placed, usually about 4″ or 5″ from the wall will be sufficient.

62. Porches.— Fig. 127 illustrates the manner of framing

the floor of a porch. Such framework should be given a pitch downward away from the house of about 1″ in 10′ that the water may be drained.

Fig. 128 illustrates the manner of placing water table and

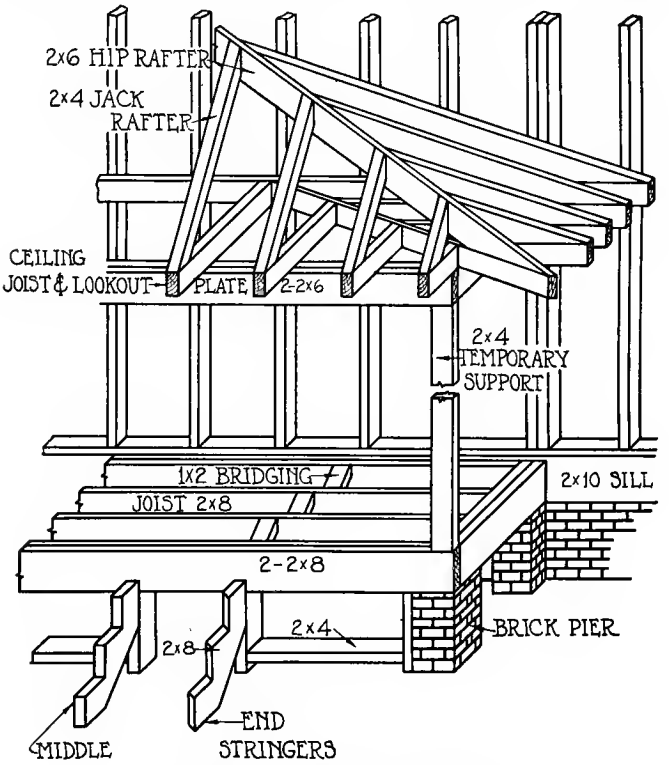


Fig. 127. Detail of Porch Framing

flooring, etc. Water table is first placed, the corners being mitered and the whole furred out from the frame about a quarter of an inch to allow any dampness to escape. Porch floors should have their joints painted with lead just before being laid.

Posts and balusters are usually placed after the porch roof has been placed, the upper frame being temporarily supported by studs.

In Fig. 127 is also shown the manner of framing the bearing

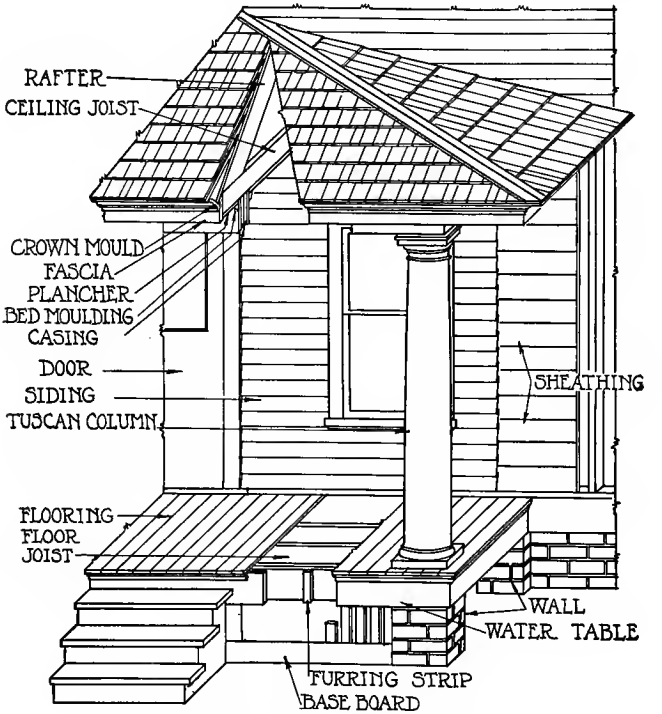


Fig. 128. Detail of Porch Finish

joists, ceiling joists and rafters for a hip roof. The various cuts are obtained in the same manner as are similar cuts on the main roof. Porch roofs are seldom given as much pitch as the main roof. They do not need as much and must, usually, be kept below the window sill line of the second story.

Fig. 128 also illustrates a common type of trim for porch

cornice. Where supporting plates are long, a flitch plate girder is formed of them by the insertion between them of a stiff plate of structural steel of suitable length and width.

63. Interior Finish.— A part of the carpenter's duty is the placing of all interior finish, such as base boards, door jambs, etc. Formerly the carpenter made, or "got out" his trim by hand but today he finds it much pleasanter and cheaper to buy the machine-made product of the mill. Even door and window frames are usually purchased from the mill, either assembled or knock-down.

64. Setting Door Jambs.— If the studs about interior door openings have been carefully selected for straightness and properly set or plumbed, the setting of the door jamb should be an easy matter. If this work has not been properly done, considerable ingenuity will be required oftentimes to get the frame set so that its edges are out of wind and the frame plumb. If a jamb should not be set plumb and out of wind, the operation of making a door fit its stops properly is a most trying one and the result usually unsatisfactory. Too much emphasis cannot be placed upon the necessity for proper placing of studs and jambs. (1) Saw off the head lugs just enough to allow the frame to be placed in the opening. (2) Cut a spacing stick of a length sufficient to reach from the floor to the under surface of the head jamb when that member is in its proper place. (3) Place the head jamb at one of its ends upon this stick and tack the jamb to the stud lightly. (4) Level the head jamb and lightly tack the second jamb, inserting wedging blocks or shingle points between the jamb and stud. A spread stick cut to hold the jambs apart properly at the base is desirable. (5) Lay a piece of finish floor against the face of each jamb and scribe along the top of this to indicate where the jambs must be cut off to fit the finish floor when it is placed. It is taken for granted that the finish floor is to be laid last. If a finish floor is not to be used, or if it is to be placed before the wall trim, the head

jamb will be leveled but not located as to height, the dividers being used to scribe the feet, being set so that the proper amount will be cut off to allow the jamb to rest at the right height when cut to the scribed lines. (6) Remove the jamb and saw to the scribed lines. (7) Replace the frame and tack it at one side after plumbing

Fig. 129. Setting Dividers at Meeting Rails

Fig. 130. Scribing Bottom of Lower Sash

it both on its face side and face edge. See that the jamb is at the right height by inserting the blocks of flooring used in scribing to length. (8) Tack the second side-jamb close to the head. (9) Sight across the edges of these jambs and adjust the loose jamb until the frame is out of wind. Plumb its face, blocking the back. Shingles placed point to point provide easy blocking where the space is not too large. A straight-edge placed against the face of a jamb will indicate whether it has been sprung in the blocking or wedging between jamb and stud.

65. Fitting Window Sash.— Sash are often fitted before the house is plastered and before the sash are glazed. (1) Joint the top and sides of the top sash, chamfering the arrises very slightly by a stroke or two with the plane. (2) Cut and fit the meeting rails about the parting stops remembering to leave a little "play," that successive coats of paint on the stops may not cause binding, $\frac{1}{16}''$ on each side is not too much. (3) Joint the edges of the lower

sash. (4) Since the bottom rail has not been beveled, only the lugs sawed off, the meeting rails will appear with reference to one another as in Fig. 129. Set a pair of dividers to a distance equal to that between the tops of the meeting rails. This can be done by placing the dividers between the meeting rails. (5) Scribe the bottom rail as indicated in Fig. 130. If the sash has been glazed so that the outer face of the bottom rail is not accessible from the inside, the scribing is to be done on the inside of the bottom rail and a T-bevel set to the slope of the sill and this used to transfer the angle to the edges of the sash. Before scribing the bottom rail, see that the meeting rails are apart a uniform distance across the sash. (6) Saw and then plane to the scribed line.

Where sash weights are to be used, they are easiest placed before lathing. The proper tying of a sash cord so that it shall not work loose with time is a matter for careful instruction by the teacher. No good carpenter will have his sash cords coming untied. The cord can be cut the estimated length after the weight has been attached, and a knot or loop tied in the free end so that the cord shall not slip thru the pulley.

In case weights are not placed before the lath and plaster, it will be necessary to make use of a "duck" to draw the end of the sash cord up thru the removed pocket cover of the jamb. This "duck" is usually a piece of lead beaten about one end of a piece of stout short cord. This lead weight is lowered thru the pulley by means of a longer cord, the end of the sash cord is then fastened to the longer cord, after removing the duck, and then drawn up and thru the pulley.

To determine the length of sash cord, draw the sash weight to the top of the jamb and, setting a sash upon the sill, mark and cut the cord about four or five inches below the opening in the edge of the sash in which the knotted end of the cord is to rest.

66. Placing Door, Window, and other Trim.— In Fig. 110-a

is shown one of the many styles of casing in common use. Base blocks and casing stock are prepared at the mill and the carpenter has but to cut these to the proper lengths and fit and attach them. (1) The base block is first placed, tho some workmen prefer to fit the base first, cutting it to a length such as will allow the proper placing of the block after the base is nailed in position. Where the finish floor is laid last, this block will be scribed at its bottom by means of a piece of flooring, otherwise the dividers would be used. (2) After the blocks are placed the casings are cut to length and nailed. (3) The head member is next made up and placed. It is customary for all door and window heads, where built up, to be constructed at one time. It should be noted that door casings are not placed flush with the face of the jamb. They should be kept back about $\frac{5}{16}''$. This is to allow the easy placing of hinges and also for appearance' sake. In all casing work the expedient of sawing under at the back should be supplemented by the use of the block plane, where necessary, that tight joints may result.

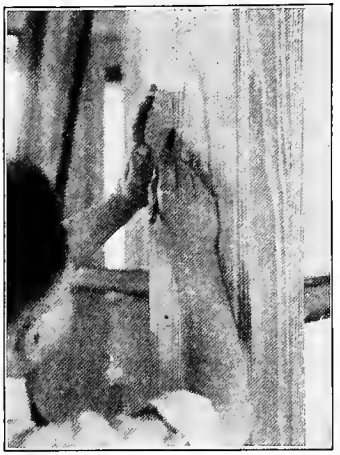


Fig. 131. Using Block to Locate Door Stop Position on Jamb

Window stool stock, like that of casings, is prepared at a mill and needs only to be cut to length and have the ends "returned" to match the face edge. (1) Lower the sash, then fit the stool to this allowing enough "play" that subsequent paint or varnish may not cause the stool to bind the lower rail of the sash. (2) Place and nail the apron. (3) Cut and place the side casings.

Note that side casings are placed flush with the face of the jambs. The crack so formed is concealed when the stop bead is placed. (4) Place the head.

Base boards and base mould may now be placed. Blocks of a thickness of the finish floor placed along the wall at frequent intervals will serve to locate the position of the base above the rough floor, when the finish floor is to be laid afterward. Internal corners of base mould and picture mould, when of irregular face, should be coped. External corners should have mitered joints. Shoe mould will be placed after the finish floor is laid.

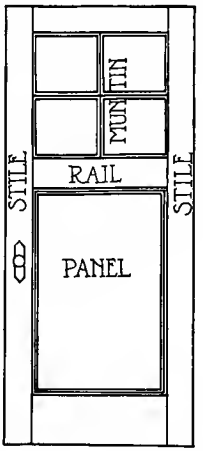


Fig. 132. Door Parts

Stop beads may next be placed in the windows and in such doors as are not rabbeted. Head stops are placed first and the side stops then coped to these. A block of a width equal to the thickness of the door will be an aid in placing stops easily, Fig. 131. Window stops should be so placed that the lower sash may move freely as it is raised.

67. Hanging Doors.— In the fitting of large doors, such as in dwellings, allowance must be made for subsequent coats of varnish or paint, usually a scant $\frac{1}{16}''$ is allowed at top and each side of a door. The bottom of a door is often not touched, except to saw away the lugs of the stiles, until after the door is hung. The door is hinged, then closed and the bottom scribed to the floor so as to allow the door to swing over rugs or carpet freely. Where a threshold is to be used, the door is scribed to fit the thickness of the proposed threshold. $\frac{1}{8}''$ should be allowed at the bottom of the door for play. If a door has a stile with a bow in its face, it should be turned so that the bow is next the stop of the lock side.

68. Fitting a Door.— The names of the parts of a door and their relative positions are indicated in Fig. 132. (1) Mark with a try-square and saw off the lugs, the parts of the stiles which project beyond the rails. (2) Plane an edge of the door until it fits the side of the frame against which it is to be hung. If the frame is straight, this edge may be planed straight. It is not wise to take for granted the squareness or straightness of a frame. A test or series of tests may first be made with square and straight-edge. A mechanic, however, usually planes an edge until it fits the frame, testing by holding the door against the frame as near to its position as its size will allow. (3) Measure the width of the frame at its top and bottom, Fig. 133, and transfer these dimensions to the top and bottom of the door, Fig. 134. When approaching the line, in planing, place the door against the frame often enough to see where the allowances must be made for irregularities in the frame. (4) Plane the top edge of the door until it fits the frame properly when the first planed edge is in position. (5) The length of the door will be determined by scribing it to the floor after being hinged.

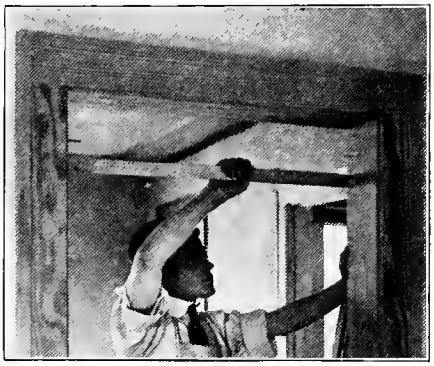


Fig. 133. Measuring Opening

The edge of the door which is to swing free is usually planed slightly lower at the back arris than at the front. An examination of the movement of an ordinary house door will show the reason for this.

69. Hinging a Door.— The hinges most commonly used in carpentry are the kind shown as butts. Where the door stands in a vertical position, hinges in which the two parts are joined by a loose pin are generally used. By removing the pins the door may be removed without taking the screws out of the hinge. Such hinges are more easily applied than those with the fixed pin. (1) Place the door in position; keep it tight against the top and the hinge side of the frame. (2) Measure from top and bottom of the door to locate the position for the top of the higher hinge and the bottom of the lower hinge. Usually, the lower hinge is placed somewhat farther from the bottom than the higher hinge is from the top. (3) With the knife or chisel mark on both door and frame at the points just located, Fig. 135. (4) Take out the door, place the hinge as in Fig. 136, and mark along the ends with a knife. In a similar manner mark the frame. Make certain that the openings on door and on frame are laid off so as to correspond before proceeding further. (5) Set the gage for the depth the hinge is to be sunk Fig. 137 and gage both door and frame. (6) Set another gage for width of openings, Fig. 138, and gage both door and frame, keeping the head of the gage against the front of the door. (7) Chisel out these gains on door and frame, Fig. 139. (8) If loose-pin butts are used, separate the parts and fasten them in place. Use a spiral drill to make openings for the screws. To insure the hinges' pulling tight against the side of the gain make the holes just a little nearer the back side of the screw hole of the hinge.

Fig. 134. Laying off Width

Put the door in place and insert the pins. It s a good mechanic who can make a door hang properly the first time it is put up. It is better, therefore, to insert but one or two screws in each part of a hinge until the door has been tried. (9) If the door hangs away from the frame on the hinge side, take it off; take off hinge on door or frame, or both if the crack is large; chisel the gain deeper at its front. By chiseling at the front only and feathering the cut toward the back, the gain needs to be cut but about one-half as deep as if the whole hinge were sunk. If the door should fail to shut because the hinge edge strikes the frame too soon, the screws of the offending hinge must be loosened and a piece of heavy paper or cardboard inserted along the entire edge of the gain. Fasten the screws and cut off the surplus paper with a knife. If plain butt hinges are used the operations are similar to those just described except that the whole hinge must be fastened to the door and the door held in place while fastening the hinges to the frame.

Fig. 135. Locating Hinge Position

Fig. 136. Knifing Hinge Location

70. Fitting Locks.— Two types of lock are in common use upon dwelling doors, the rim and the mortise lock. The rim lock, Fig. 140, is used upon cheap

construction and is attached to the outer surface of the door. The mortise lock is used upon the better class of work; the box is housed into a mortise and the selvage into a gain cut into the edge of the door stile. Door locks are made so that the bolts may be reversed to fit either right or left hand doors. This is accomp-

Fig. 137. Setting Gage for Depth of Gain

Fig. 138. Setting gage for Width of Gain

lished by removing a screw in the side of the box and carefully lifting the bolt, replacing it in reversed position. A right hand door is one which swings to the right when pushed open.

Fig. 139. Gain Ready for Hinge

To attach a rim lock: (1) Place the lock against the side of the door and mark thru the key hole and knob spindle hole with a sharp awl or divider point. (2) Remove the lock and bore appropriate sized holes. (3) Fasten the lock and place the escutcheons, knob spindle and knobs. (4) Locate and attach the strike or latch plate.

To place a mortise lock, Fig. 141: (1) In a manner similar to that used in placing the rim lock, locate the knob spindle and

key holes. A more accurate result is obtained if the knob spindle hole is located by four points, one at each corner of the square, Fig. 142. In placing the lock, keep the selvage back from the edge of the door a scant $\frac{1}{16}''$ so that the selvage may be sunk below the edge of the door by that amount when mortised in. This will permit the door to be trimmed without the removal of the lock in case the door should swell after being fitted and locked. (2) Bore the holes for knob spindle and key. (3) Locate a center line on the edge of the stile and bore for the mortise which shall receive the box of the lock. (4) Place the box and then mark about the protruding selvage using a sharp knife, Fig. 143. (5) Remove the lock and "gain in" the selvage, Fig. 144. (6) Fasten the lock by means of the screws thru the selvage and attach the escutcheons, knob spindle and knobs. (7) Close the door and mark the vertical position of the latch upon the jamb. (8) Open the door and place the latch or strike plate, locating its vertical

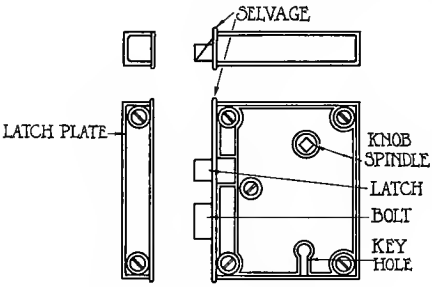


Fig. 140. Rim Lock

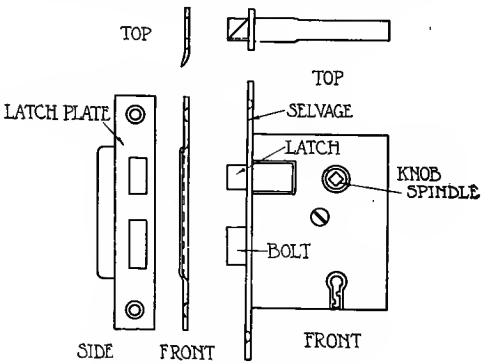


Fig. 141. Mortise Lock

position by means of the knife marks just made upon the jamb, and its horizontal position by a measurement taken from the latch to the face of the door; transfer to the jamb by rule or gage. (9) Scribe about the plate and then gain it into the jamb. On a door with a rabbeted jamb instead of an adjustable stop, the essential measurement will be from the back arris of the stile to the front of the latch. (10) Attach the plate, then chisel out the openings for latch and bolt.

Fig. 142. Locating Knob Spindle Hole

Equally common is the practice of taking step (3) first, with steps (1) and (2) taken after step (5).

71. Laying and Scraping Floors. — Quarter-sawed stock makes the best wearing floor. However, oak wears well in either plain or quarter-sawed forms. All hard wood finish floors are milled with tongues and grooves on edges and ends. Holes for nailing are usually drilled at the mill also.

In laying a finish floor, it is not advisable to lay it with its lengths extending in the same direction as those of the rough floor. The shrinkage of the wide boards of the under floor will open unseemly cracks in the finish floor. Where it is necessary to run lengths for both floors in the same direction the finish floor should be separated from the rough floor by thin furring, such as lath, placed 16″ apart. Rough floors laid diagonally overcome this difficulty. Paper is usually placed between the two floors. Care should be taken in starting a floor to select straight boards. Where grooves fail to fit tongues of boards that are laid, a piece of 2″x4″ about 3′ or 4′ long should be used as a pounding block that the

tongue of the board being laid may not be battered, the most common cause of trouble in floor laying. Nails are driven "toeing" thru the board just above the tongue that the heads may be concealed and also to better draw the board in position. Hammer marks showing upon the face of a floor indicate carelessness. It is

Fig. 143. Locating Selvage Gain

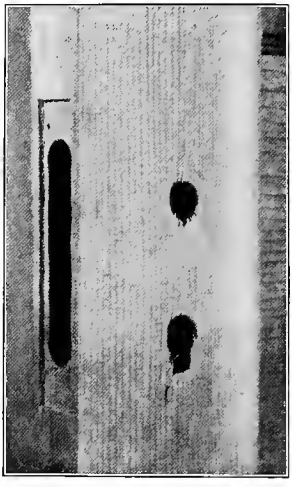


Fig. 144. Ready for the Lock

not necessary that nails should always strike joists, for a good rough floor will hold such nails with sufficient firmness. Where nails must be driven into hard maple, a hole must be drilled first. On the great majority of hard woods the dipping of the point of the nail in soap or oil will cause it to enter the wood with careful driving, without the drilling of a hole.

After a hardwood floor has been laid it should be scraped. Scraping floors is a tedious task at best. Electrically driven machines now relieve the carpenter of much of this work, the floors being laid and finished by a specialist in floor work. The shoe

mould is placed last, being nailed to the floor, so that any shrinkage of the joists will cause the mould to drop with the floor. Base board and shoe mould should be stained, but not varnished, before the mould is placed.

On account of waste in tonguing and grooving and straightening flooring stock, an allowance of from $\frac{1}{8}$ to $\frac{1}{4}$ extra is necessary in estimating.

72. Door and Window Frames. — Like other carpentry detail, window and door frames may be constructed in any one of a number of styles. Fig. 145 illustrates a satisfactory type of door frame for cottage use. The sill will be given a pitch or fall of 1″ in 12″ and will have its ends housed into the jambs. The jambs will be assembled first, being nailed together. Next, the side casings are fitted at their lower ends, cut to length and nailed. Frequently they are nailed and then cut to length. The head casing with its cap is next placed.

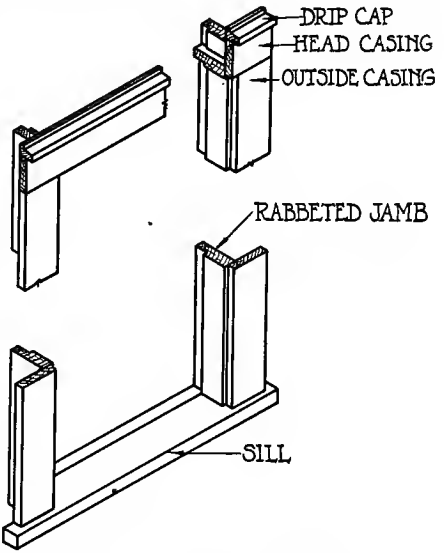


Fig. 145. Detail of Door Frame

Fig. 146 illustrates a common type of cottage window frame. The method of procedure is not unlike that described for the door frame. The sill will be grooved on its under side to receive the top edge of the siding board and given a fall of 1″ in 10″. Jambs must be grooved to receive a parting stop as shown. Where

weights are to be used each jamb must have a pocket as detailed. The stock sawed out of the jamb may be made use of for pocket cover stock by proper manipulation. Pulleys may be placed before the jambs are assembled, at least the holes for them should be prepared.

There are a number of "tricks of the trade" in frame making. Their presentation must be left to the instructor, for the making of frames belongs to millwork and space can be spared here for general directions only.

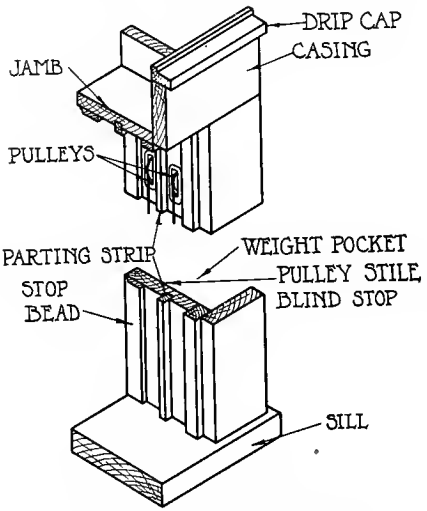


Fig. 146. Detail of Window Frame

73. Woodwork in Masonry Structures.—Wood framing in brick and other masonry buildings is but slightly different from that wholly in wood. Fig. 147 illustrates the manner of framing the ends of joists which rest in solid masonry walls. The ends are shaped as indicated so that, in case of fire, the floors in falling will not pull over the walls, but will fall free. Anchors are used to tie the building together, and these are to be placed near the lower edge of the joists so that they may split out of the joists easily or allow the floor to drop free, in case of a falling of the floor and joists.

A popular type of construction is that known as brick veneer, Fig. 148. It consists of an ordinary framed house with a covering of brick as shown. These bricks are fastened to the wall by

metallic bonds. From the outside, the building has all of the appearance of solid brick, while it is claimed that a wall so formed is warmer than one of solid brick.

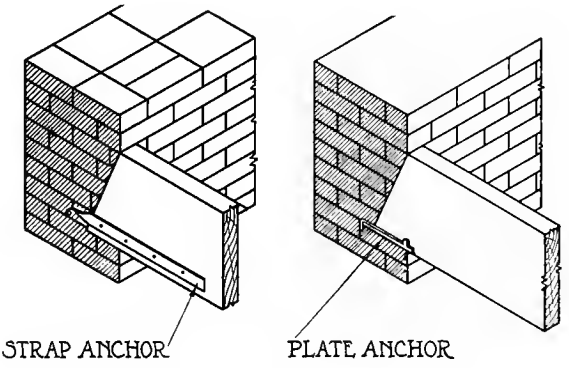


Fig. 147-a Fig. 147-b

Joist Framed into Brick Wall

Over openings in brick walls, lintels are required to support the arch, Fig. 150.

Fig. 149 shows the manner of framing a window opening for

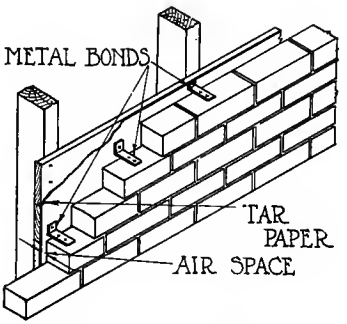


Fig. 148. Brick Veneer

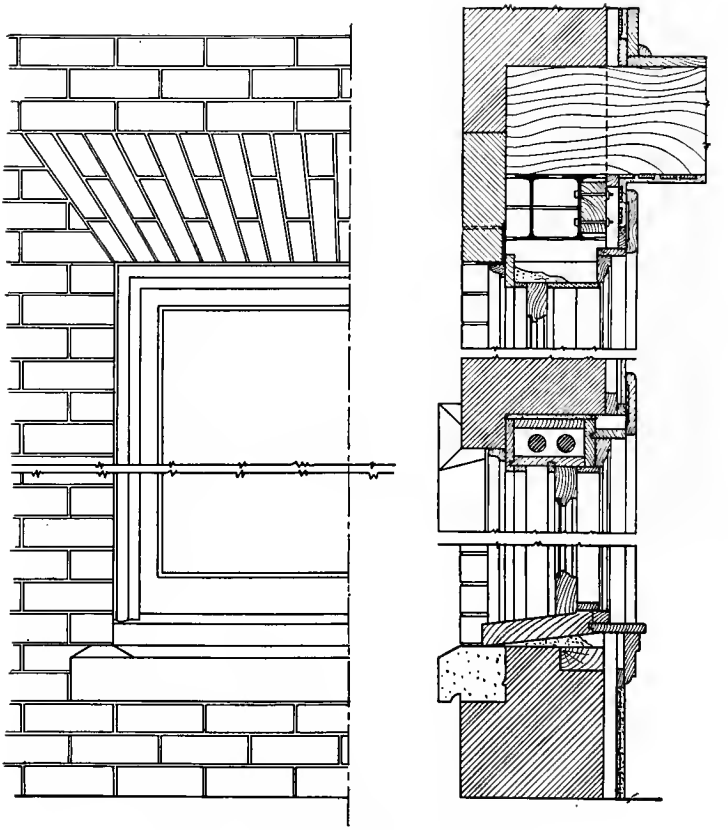


Fig. 149. Window Detail for Brick Wall

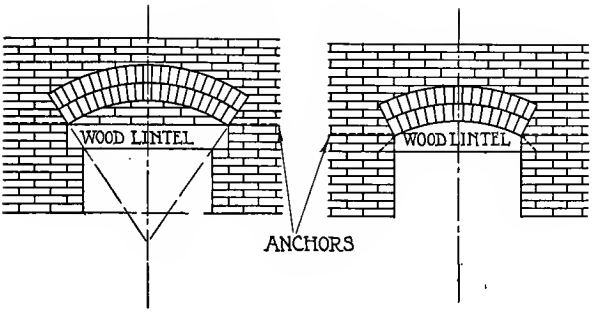


Fig. 150. Lintels

a brick wall. Fig. 151 illustrates the manner of attaching a plate to a brick wall.

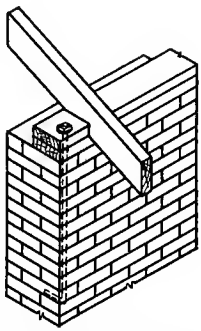


Fig. 151. Attaching Plate to Brick Wall

CHAPTER VII

Estimating

74. Methods of Estimating.— Building costs may be divided into two main divisions, cost of material and cost of labor. There is but one so-called safe way to figure or estimate the cost of any particular piece of carpentry work. This consists in "taking off" the material quantities in detail and to this adding the labor cost of placing the same. This is the method in common use by contractors in making a final estimate. Where a rough or working estimate is required, such as an architect's estimate of the probable cost of a building planned by him, two methods may be used. One consists in figuring the cubical contents in feet and multiplying a predetermined, or unit price per cubic foot for that type of house. Ordinarily, the main frame is figured, counting from the basement floor to the top of the attic walls that are, or may be finished — outside measurements. Porches and open spaces are not figured. A second method consists in estimating the number of squares (100 sq. ft.) of side wall, of partitions, of floors, etc., and multiplying a predetermined price per square for a similar type of building. This latter method is more accurate than the cubic-foot unit method.

75. Table for Estimating by Cubic-Foot Unit.— The following table of unit prices will give a rough working estimate for various types of building differentiated after the custom of insurance adjusters. The prices are for 1915 and to be of any value must be compared with known costs of similar structures in the community in which they are to be used. Any evident variations in unit costs so discovered should be noted and corrections made.

CUBIC-FOOT UNIT ESTIMATE

COUNTRY PROPERTY	PER CUBIC FOOT
Frame dwelling, small box house, no cornice	5c
Frame dwelling, shingle roof, small cornice, no sash weights, plain	6¼– 7½c
Brick dwelling, same class	8¾–10c
Frame dwelling, shingle roof, good cornice, sash weights, blinds (good house)	8¾–10c
Brick dwelling, same class	11¼–12½c
Frame barn, shingle roof, not painted, plain finish	2¼– 3¼c
Frame barn, shingle roof, painted, good foundation	3 – 4¼c
Frame store, shingle roof, painted, plain finish	6¼– 8¾c
Brick store, shingle roof, painted, good cornice, well finished	8¾–11¼c
Frame church or school house, ordinary	6¼– 8¾c
Brick church or school house, ordinary	10 –12½c
If slate or metal roof, add ¼c per cubic foot.	
CITY PROPERTY	
Frame dwelling, shingle roof, pine floors and finish, no bath or furnace, plain finish (good house)	7½– 8¾c
Brick dwelling, same class	10 –11¼c
Frame dwelling, shingle roof, hardwood floors in hall and parlor, bath, furnace, fair plumbing	10 –11¼c
Brick dwelling same class	10 –12½c
Frame dwelling, shingle roof, hardwood in first floor, good plumbing, furnace, artistic design, some interior ornamentation, well painted	12½–15c
Brick dwelling, good plumbing, bath, furnace, pine finish, well painted	13¾–15c

76. Grading Rules.— There is no uniformity as to grades of lumber. Fifteen or more associations have rules for inspection and classification of lumber and these rules vary with the association and from year to year in the same association. The following rules taken from a catalogue of a middle west lumber concern will be found helpful:

YELLOW PINE DIMENSION, STUDDING, JOISTS AND TIMBERS

No. 1 Common.— The best grade and the one recommended for use on first class jobs.

No. 2 Common.— Dimension up to 20 feet long only can be obtained in this grade. Timbers are not manufactured in No. 2. This stock will show defects not found in No. 1 grade, and some pieces are not entirely straight. It is a sound, serviceable grade, but not recommended for first class work.

YELLOW PINE BOARDS, SHEATHING, SHIPLAP, AND FENCING

No. 1 Common.— This grade is not clear, but is strictly sound and uniform in thickness and width. It is used on the best classes of work, for barn boards, and wherever exposed to wear and weather.

No. 2 Common.— This grade is sound but contains more sound knots than No. 1 and is somewhat coarser. It is mostly used on first class jobs for sub or rough floors, and for sheathing under siding. It can be used for outside work, but is not recommended for this purpose except upon cheap buildings.

No. 3 Common.— A fairly good lower grade which will work up nicely but with some waste due to cutting out defects. Runs uneven in quality. Makes a fair subfloor or sheathing.

YELLOW PINE FLOORING, CEILING, PARTITION, AND DROP SIDING

Clear Grade.— The best grade manufactured. Practically free from defects and the grade used upon first class jobs. Is strong, sound, and will lay without waste due to cutting out of imperfections. Should be used when a natural finish is desired.

No. 1 Common.— This grade will contain small, sound knots, sap stains, pitch or pitch pockets. It is sound and durable, and a good grade for ordinary work or wherever covered with paint.

No. 2 Common.— Coarser than No. 1 grade; will lay up with little waste. Is sound, and flooring of this grade is often used for sheathing or sub flooring where a warm, tight job is desired. Can also be used on cheap painted jobs.

FIR BOARDS, TIMBERS, DROP SIDING, CEILING AND FLOORING

Select No. 1 Barn Boards.— This grade is especially selected and is better than No. 1.

No. 1 Timbers.— Good sound straight stock, to be used for sills and posts subjected to moisture.

Clear Ceiling.— Free from defects. Good for cornice work and porch ceilings.

Edge Grain Flooring, Clear Grade.— Especially suited to porch floors as it wears well and resists effects of moisture.

Clear Drop Siding.— Contains no sap, shakes or other defects.

SHINGLES, LAP SIDING, Y. P. AND CYPRESS FINISH, WHITE PINE BOARDS

5 to 2 Clears.— The heaviest grade — five shingles laid one on top of the other will measure 2″ at the butts.

6 to 2 Extra Star A Star.— A lighter grade, but clear and 16″, as are the 5 to 2″ grade.

Bevel or Lap Siding.— Carried in stock in red cedar, redwood, cypress, and white pine. "Clear" is free from all defects.

Cypress "C" Grade.— Has small sound knots and other slight defects such as can be covered with paint. All siding is bundled 10 pieces to the bunch in random lengths. Not furnished in specified lengths.

Yellow Pine and Cypress Finish.— This stock in "clear" grade is practically free from defects. The yellow pine is suitable for interior finish. Cypress is suitable for inside finish or for cornice work on first class jobs. "*C*" cypress finish contains some knots and other slight defects. Is suitable for outside finish on ordinary jobs.

White Pine Boards.— As a rule, carried in stock only in No. 1 grade. Nothing but sound, red-knotted boards should be included. No shakes. Excellent for exposure to weather.

77. Estimating Lumber Quantities.— Lumber is measured in terms of the board foot as a unit, 12″ by 12″ by 1″ or its equivalent, indicated by the abbreviation B. M. (board measure).

Example:
Determine the B. M. in a girder 6″ by 8″ by 16′.

Solution:
Rule—Thickness in inches times width in inches, divided by 12″ times the length in feet gives a number equal to the number of board feet.

$$\frac{6'' \times 8''}{12} \times 16' = 64' \text{ B.M.}$$

Stock less than 1″ thick is figured as 1″ thick. In commercial practice lumbermen make use of tables in determining quantities. Appendix III.

In estimating quantities, suitable allowance must be made for waste. This waste is incurred (1) thru loss when boards or planks are cut to required lengths. Standard lengths are 10′, 12′, 14′, etc., and these will not always cut to advantage. (2) Waste is incurred in machining the stock, as dressing, edging, tonguing and grooving. Necessary allowances will be indicated herein.

Heavy Timbers.— Girders, posts, etc., are determined by count.

Joists.— To determine the number of joists required for a room or a building, count the actual number required beginning at a wall (¾ times number of feet in length or width of room when set 16″ on centers), and to this add one joist to be placed against the second wall.

Cataloged or listed sizes are for lumber fresh from the saw. Shrinkage due to seasoning and surfacing one side and one edge so that the stock may have uniform thickness and width will give actual sizes as follows: 2″ x 4″ when sized on one side and one edge, will give 1⅝″ x 3⅝″; 2″ x 6″, *S*-1-*S* and 1*E*, 1⅝″ x 5⅝″; 2″ x 8″, *S*-1-*S* and 1*E* gives 1⅝″ x 7½″; 2″ x 10″, *S*-1-*S* and 1*E* gives 1⅝″ x 9½″; 2″ x 12″, *S*-1-*S* and 1*E* gives 1⅝ x 11½. When

S-2-*S* and 2*E*, or sized on 4 sides, stock will measure $\frac{1}{8}$″ less than indicated above.

Studs for Walls and Partitions.— Count one for each lineal foot of wall or partition, where specified 16″ on centers. The extra studs are to be used in doubling corners, at doors and windows, and in gables. Barns and sheds will not require these extra studs.

Bridging.—Allow 25 lineal feet of 2″ by 4″ for each square of flooring.

Rafters.— On a plain roof, count actual number and add one, as in counting for joists.

Sheathing.— Calculate the exact surface to be covered, deduct openings; then, for unmatched sheathing or barn boards or fencing, as it is also called, add $\frac{1}{12}$ for 12″ boards, $\frac{1}{10}$ for 10″ boards and $\frac{1}{8}$ where 8″ boards are used. Four inch and 6″ are seldom laid solid, being used mainly for roof sheathing for shingle roofs, and laid 2″ apart. These additions are due to the fact that thru seasoning and dressing, a 12″ board becomes 11$\frac{1}{2}$″, a 10″ becomes 9$\frac{5}{8}$″, an 8″ becomes 7$\frac{3}{4}$″, a 6″ becomes 5$\frac{3}{4}$″ and a 4″ becomes 3$\frac{3}{4}$″. The additions specified allow for waste in cutting.

Shiplap.— Calculate the exact surface to be covered, deduct openings; then add for floors 17%, for sidewalls 20%, for roofs 25%.

Sheathing laid with 2″ spaces should have proportionate deductions made, that is, on 1″ x 6″, figure as if laid solid, then deduct $\frac{1}{4}$; for 1″ x 4″ deduct $\frac{1}{3}$. Sheathing when matched, such as is used sometimes for sub-floors and side walls and roof sheathing under slate roofs and better known as flooring, will be estimated by figuring the exact surface to be covered, deducting the openings, then adding for 6″ stock, which is the kind most always used, 15% for floors, 17% for sidewalls, and 20% for roofs.

If shiplap or matched sheathing is laid diagonally add 5% for waste due to lack of ability to reverse cut.

Siding.— For bevel siding, calculate the exact surface, deduct openings; then add for 6″ siding when laid 4½″ to the weather, 33%; for the 4″ siding add 50%.

Drop Siding.— Drop siding, ceiling and wainscoting are figured just like matched flooring, which is described below.

Flooring.— For square edge, calculate the exact surface to be covered, add for 6″ flooring 11% for waste in matching, etc.; for 4″ flooring add 20%. It is becoming common practice to specify flooring by actual face measurement after being machined. The following figures are for actual surface measurements.

For matched flooring, calculate the exact surface to be covered, then add 20% for 5¼″ flooring, for 3¼″ flooring add 25%, for 2¼″ add 33%, for 1½″ add 40%.

Flooring less than 1″ thick, like all other lumber, is estimated as 1″ thick.

Shingles.— A bunch of shingles contains the equivalent of 250 shingles of 4″ average width. With an exposure of 4½″ to the weather a 4″ average shingle will cover 18 square inches, making 800 shingles to the square. Waste in doubling the first course and in laying will necessitate an addition of 8% on a plain roof and 12% on hips or on gabled walls. Cost estimates are based upon the M. or 1000.

SHINGLES PER SQUARE

Plain roof, 4 ″ exposure, 990; roof cut up, 1010
Plain roof, 4½″ exposure, 880; roof cut up, 900
Plain roof, 5 ″ exposure, 790; roof cut up, 810

Lath.— Lath for interior plaster work are usually ⅜″ by 1⅜″ by 4′, put up in bundles of 50 each and are sold by the 1000. 1000 lath will cover 70 yards of surface and will require 8 lbs. of 3d fine lath nails. Lathing is usually considered a part of the plasterer's contract. There is no uniformity of practice as to the deduction for openings.

Building Papers.— The cheapest is "rosin sized," and is not waterproof. This is used mainly under floors and upon side walls under bevel siding. It is sold by the pound in rolls each 36″ wide containing 500 square feet.

Dry felt is used where better protection from cold is desired. In the cheaper grades, the material is made of wood fiber and rosin. In the better grades wool is used. Tar felt, used where moisture is to be resisted, is dry felt saturated with tar. These materials are sold by the pound: 12, 15, and 20 lbs. to the 100 square feet, in rolls of various widths. A catalog should be consulted for weights and covering capacity.

78. Estimating Millwork Quantities.— The number of doors and windows will be determined by an actual count.

Mouldings, casings, baseboard when moulded, window stools, etc., are sold by the 100 feet lineal measure, random lengths. Extra charge is made for specified lengths where the quantities are determined by scale measurements of the plan and elevations. Window frames of stock sizes, door frames, inside jambs, stair parts, buffets, etc., will be found priced in millmen's catalogs, and assist greatly in determining prices for ordinary work. This text cannot give space to list such data, which is so readily obtained from commercial catalogs.

79. Example of Form for Bill of Materials.—

BILL

Ticket or Catalog Number	No. of Feet	No. of Pieces	Size	Length	Description	Price				
						Rate		Extensions		
	270	30	2x4	14	Y. P., S1S and 1E	22		5	94	
		2	M		5–2″ red cedar shingles	3	55	7	10	
	300	1x6			⅝ 2 Y. P.— flooring	20		6	00	19 04

80. Estimating Labor Costs.*— In estimating labor costs the following data is to be made use of. The estimator will have to determine the hours per day and the scale of wages per hour paid in his locality, and make whatever changes in the data is necessary. He should also compare the quantity of work done by men he may observe with that given herewith. The time data herewith is based upon the work of one mechanic who has mastered his trade fairly well. With an efficient foreman and a selected group of workmen these time allowances can be reduced in many instances as much as one-half. Experience alone will determine the possibilities of such reductions with safety.

COST OF PLACING FRAME AND COVERING

By One Man

	HRS. PER 1000 B.M. FT.
Sills and plates 6″×8″, no gains or mortises	20
Sills and plates 6″×8″, gains no mortises	40
Sills and plates 6″×8″, gains and mortises	60
Joists and box sills	20
Studding 2″×4″	32
Studding 2″×6″	23
Rafters 2″×4″, plain gable roof	40
Rafters 2″×4″, hip roof add 5% to 30% for each hip or valley.	
Rafters 2″×6″, plain gable roof	27
Rafters 2″×6″, hip roof add 5% to 30% for each hip or valley.	
Sheathing, square edged, horizontal, walls	16
Sheathing, square edged, diagonal, walls	19
Sheathing, 6″ matched, walls	24
Sheathing, 6″ matched, walls diagonal	32
Sheathing for floors, sub-floors, square edged	10
Sheathing for floors, sub-floors, square edged diagonal	12
Roof Sheathing, plain gable roof	13
Roof Sheathing, hip roof	20

* For a more complete treatise of labor costs, the student is referred to Gillette's Handbook of Cost Data, Section X, the source, in the main, of the basis of this data.

COST OF PLACING FRAME AND COVERING—(*Continued*)

	HRS. PER 1000 LIN. FT.
Cornices	400 to 800
Water table, 3 member	220
Corner boards	73
Belt	195
	HRS. PER M.
Shingling, plain roof, new work	3½
Shingling, hips and valleys, add 5% for each hip or valley.	
Shingling, old work, add 20% for labor in removing old shingles.	
Shingling side walls, plain	5½
Shingling side walls, fancy	8
	HRS. PER 1000 B.M. FT.
Siding, bevel, 6″	35
Siding, bevel, 4″	42
Siding, shiplap	27
Siding, drop, when window and door casings and corner boards are placed over siding	20
Siding, drop, when jointed between casings and corner boards	32
Surfaced barn boards	11½
Ceiling, store	53
Wainscoting, cut, put up, finished with cap and ¼ round, in a dwelling	46

COST OF PLACING FLOORS

By One Man

	HRS. PER 1000 B.M. FT.
Floors, pine	35
Floors, yellow pine, 3¼″ face, laid on sheathing, including paper between, smoothing rough joints, business block	40
Floors, yellow pine, 3¼″ face, laid direct on joist, no smoothing	26⅔
Floors, yellow pine, 3¼″ face, smoothed and sanded	45
Floors, maple, 2¼″ face, laid not smoothed	40
Floors, maple, 2¼″ face, laid and smoothed	80
Floors, maple, 1½″ face, laid and well smoothed	107
Floors, oak, fine floor, glued, smoothed, scraped, sand papered	320

COST OF BRIDGING AND FURRING

	HRS. PER 1000 LIN. FT.
Bridging	65
Placing plaster grounds	20

COST OF PLACING BASEBOARDS

	HRS. PER 100 LIN. FT.
Baseboard, three member, hardwood, average number miters	10
Baseboard, two member, scribed to floor	16
Baseboard, plain, ¼ round at floor	8
Moulding, bed, flat, 3″	2½

COST OF PLACING DOORS, WINDOWS, BLINDS

	HRS. ON EACH
Window, to put together when K. D. (knock-down)	1½
Window, making frame	3
Window, setting frame	¾
Window, setting frame in brickwork	1
Window, fitting and hanging sash per pair	1
Window, hanging blinds per pair, before frames are set	¾
Window, hanging blinds per pair, after frames are set	2
Window, casing inside	2
Window, ordinary pine in frame building, including setting of frame	5
Window, same but hardwood	6½
Window, ordinary pine in brick building, including setting of frame	6½
Window, same but hardwood	9
Window, attic and cellar	1¾
Door, making frame	2½
Door, making frame with transom	3½
Door, common hardwood, set jambs, case, hang and finish, including transom	10
Door, common 1⅜″ pine complete	4½
Door, common 1¾″ pine complete	5½
Door, casing opening one side	¾
Door, casing opening both sides	1½
Door, fitting, hanging and trimming	1½
Door, fitting, hanging and trimming outside door, pine	2½
Door, fitting, hanging and trimming outside door, oak	4
Sliding doors, pine, (framing not included) to finish complete with lining, jambs, casing and hardware, per pair	32
Sliding doors, same, but hardwood	48
Sliding doors for barn 12′×18′	24
Transom, fixed	1
Transom, hung	1½

COST OF STAIR WORK

	HRS. LABOR ON EACH
Box stair, cellar or attic	25
One flight plain stair, 7-room house, hand rail, balusters	40
One flight fine stair, 9-room house, handrail, paneled	100

PORCHES IN GENERAL

Hours per lineal foot	5
Balustrade hours per 1000 lineal feet	500
Lattice for porches, hours per 1000 square feet	16 to 200

LATH

Lath, hours per 1000	7

MISCELLANEOUS LABOR ITEMS

Paneling, pine, hours per 100 sq. ft	50
Paneling, hardwood, hours per 100 sq. ft	83
Drawers, dovetailed, hours, each	2½
Drawers, 15″×18″, including racks and fittings	2
Shelves, in storeroom, dadoed into compartments 18″ square, hours per 100 sq. ft	62½
Shelves, pantry, no dado, hours per 100 sq. ft. shelf	37½
Closet hooks on strip of wood, 12″ apart, hours per 100 lineal feet	15
Sideboard, oak, 8′×8′, hours	100

81. Estimating Quantities of Nails.—The following table will enable one to estimate the quantity of nails required for the various kinds of common carpentry. The table of length and number of nails to the pound, Appendix III, may be made use of in determining nail estimates for other kinds of work not here specified.

QUANTITIES OF NAILS

MATERIALS		POUNDS	SIZE	KIND
Joists and sills	per 1000 B.M. ft.	25	20d	common.
Studding	per 1000 B.M. ft.	15	10d	common.
Rafters	per 1000 B.M. ft.	15	10d	common.
Sheathing, drop siding, shiplap	per 1000 B.M. ft.	20	8d	common.
Cornice	per 1000 lin. ft.	18	8d	common.
Shingling	per 1000	4	4d	common.
Bevel siding	per 1000 B.M. ft.	18	6d	common.
Ceiling, wainscoting	per 1000 B.M. ft.	20	6d	common.
Floors, pine	per 1000 B.M. ft.	30	8d	common.
Floors, hardwood	per 1000 B.M. ft.	30	6d	common.
Baseboard	per 1000 B.M. ft.	12	8d	finish.
Window trim, one side		¾	8d	finish.
Door trim, one side		¾	8d	finish.
Lath	per 1000	8	3d	common.fine.
Lattice for porches	per 1000 sq. ft.	20	3d	common.
Balustrade	per 1000 lin. ft.	18	6d	casing.

82. Example of Form for Carpentry Costs.— The following form, used by a practical carpenter, and published in the Correspondence Department of *The American Carpenter and Builder*, should suggest means whereby the data just given may be made more readily available for estimating purposes.

It must be remembered in interpreting all such data that costs will vary greatly with conditions. A carpenter, for illustration, who gives his time and attention to general carpentry cannot lay shingles with the speed a specialist in shingling can. Again, a carpenter cannot make window and door frames by hand with the same speed that these can be made by machinery in a mill. The prices given herewith are for work done by a general carpentry mechanic. The estimator should test out these figures to see how they compare with actual working conditions in his community. The following table is made for "country" conditions, the men working at 30c per hour, 9 hours a day.

MATERIALS IN PLACE AT 30c PER HOUR

Various Materials	Ft. per 9-hrs. 2 Men	Hrs. per 1000 Ft.	Cost of Labor		Nails	
			M Ft.	L or Sq.	Lbs.	Size
Joists and sills	900	20	$6.00	....	25	20d
Studding, placed	600	30	9.00	....	15	10d
Rafters	450	40	12.00	....	15	10d
Sheathing, vertical	750	24	7.20	....	20	8d
Sheathing, diagonal	562	32	9.60	....	20	8d
Bevel siding	514	35	10.50	....	18	6d
Cornices	45	400	.....	.12 –L	18	8d
Shingling, new roofs	4000	4½	1.35	....	4	4d
Lathing for plaster	2572	7	2.10	....	8	3d
Lattice for porches	1125	16	4.80	....	20	3d
Balustrade for porches	36	500	....	.15 –L	18	6d
Base boards, 8″ pine	216	83	24.90	.02½–L	12	8d
Base boards, 8″ hardwood	108	166	49.80	.05 –L	..	..
Floors, laid, pine	514	35	10.50	....	30	8d
Floors laid, hardwood	100	180	54.00	.05½–L	30	6d
Floors cleaned, hardwood	100	180	54.00	.05½–L	..	..
Wainscoting, pine	54	...	.....	.10 –L	20	6d
Paneling, pine	36	...	.....	.15 –Sq	..	..
Paneling, hardwood	22	...	.....	.25 –Sq	..	..
Porches and verandas	..	...	....	1.50 –L	18	8d

M = 1000 Ft. L = Lineal Sq = Square Feet.

Shingles are for new roofs; where hips and valleys are required add 5% additional for each one; where old shingles and nails must be removed, add again (20% to total) for this work.

The above rate is based on figures of 30c per hour. For other rates the following will apply in addition: At 35c per hour add 17%; at 40c add 34%; at 45c add 51%; and at 50c per hour add 68%.

Example:

(*A*) Take 1,000 feet of hardwood floor to be cleaned at 50c per hour = $54.00 + $36.72 = $90.72

Looking again we find it would take 180 hours at 50c per hour = $90.00

(*B*) Take 1,000 feet of joists to be placed at 50c per hour = $6.00 + $4.08 = $10.08.

Looking for the hours we find it would take 20 at 50c, or $10.00.

83. Total Building Costs by Percentages.— Having carefully estimated the costs of one or two of the large items in a building, such as lumber or millwork or labor, the total cost of a building may be approximated with a fair degree of accuracy by a general contractor by means of the following table of percentages. Foundations or any other parts of a building which may be unusual should be excluded and figured separately in detail. In any event, before a building is finally completed the contractor will have to settle with each sub-contractor upon the basis of detailed cost estimates. Where time is available, the contractor as a rule secures bids from the various sub-contractors, such as the plumber, the lather, the mason, etc., combining these and adding his commission of 10% for oversight, and an additional 10% for incidentals or contingencies.

COSTS BY PERCENTAGES

Items	Frame Building	Brick Dwelling
Excavation, brick and cut stone	16%	36%
Plastering and materials, including lathing	8	6
Millwork including glass and glazing	21	20
Lumber	19	12
Carpentry labor	18	10
Hardware	3½	3
Tinwork and galvanized iron	2½	4½
Plumbing and gas fitting and materials	7	3
Painting and materials	5	5½
Heating (not included)		
Total	100%	100%

Example:

A lumber bill for a given frame house is found to "figure" $500, determine the approximate cost of the various sub-contracts, and for the house as a whole.

Solution:

$500 = 19\%$ of the total cost.

Total cost = $2632 (exclusive of heating).

Excavation, brick and cement work = 16% of $2632	=	$421.12
Plastering = 8% of $2632	=	210.56
Millwork and glazing = 21% of $2632	=	552.72
Carpentry labor = 18% of $2632	=	473.76
Hardware = 3½% of $2632	=	92.12
Tinwork = 2½% of $2632	=	65.80
Plumbing = 7% of $2632	=	184.24
Painting = 5% of $2632	=	131.60
Lumber	=	500.00
		$2631.92

To this must be added heating, electric wiring, electric and gas fixtures, window shades, cement walks, sewerage, grading, decoration of walls, architect's fee and contractor's commission.

For furnace heat, add 6 to 7%; for steam, add 8 to 10%; for hot water, add 10 to 12% additional.

For electric wiring, add 1¼%. For fixtures, electric and gas, add 2 to 3%.

To this total add 10% for incidentals and contingencies; add 10% for contractor's charge. Above this amount add 6% for architect's fee, to get the cost to the owner.

Such a method of estimating should not be mistaken for anything but fairly safe approximation where normal conditions exist.

APPENDIX I

Natural Trigonometric Functions.— Consider the angle DAE, Fig. 152. From any point on the line AD drop a line perpendicular to the side AE forming the right triangle ABC. Let a represent the value or length of the side BC; let b represent the value of the side AC; let c represent the value of the side AB. The ratio of the side a to the side c is called the sine of the angle A. More

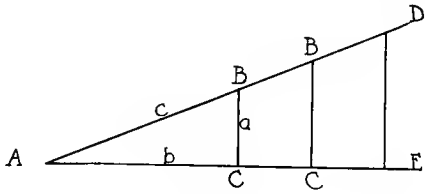


Fig. 152

concisely stated, $\frac{a}{c} = \sin A$. The sine of an angle is the ratio of its opposite side to its hypotenuse, or opposite side over hypotenuse = sine of angle A = sin A. In a similar manner:

$$\frac{b}{c} = \frac{\text{adjacent side}}{\text{hypotenuse}} = \text{cosine of angle } A = \cos A.$$

$$\frac{a}{b} = \frac{\text{opposite side}}{\text{adjacent side}} = \text{tangent of angle } A = \tan A.$$

$$\frac{b}{a} = \frac{\text{adjacent side}}{\text{opposite side}} = \text{cotangent of angle } A = \cot A.$$

$$\frac{c}{b} = \frac{\text{hypotenuse}}{\text{adjacent side}} = \text{secant of angle } A = \sec A.$$

$$\frac{c}{a} = \frac{\text{hypotenuse}}{\text{opposite side}} = \text{cosecant of angle } A = \csc A.$$

These ratios are known as natural functions of the angle because their values change with every change in the value of the angle.

The lengthening of the sides of the angle should not be mistaken for a change in the value of the angle. Draw to scale very carefully any angle and drop lines from any two points, as at B and B', Fig. 152, which shall be perpendicular to the base line. Measure the sides of the triangles so formed and express their ratios as functions of the angle A. Comparing like functions of large and small triangle it will be seen that once an angle is known in degrees, its sine, cosine, etc., are determined irrespective of the length of sides. And, vice versa, if we know the functional values or ratios of certain sides of the right triangle formed about an angle, we have determined the value of the angle in degrees. The Table of Natural Trigonometric Functions, Appendix II, is nothing more than a compilation of these various ratios carefully figured out and placed in the form of a table to assist in the easy solution of problems having to do with the finding of certain parts of a triangle when other parts are given.

With a protractor, measure the angle A of the triangle whose sides were just measured, and compare the ratios of the sides or the functional values with those given in the Table, Appendix III, for the same angle. The larger the scale of the drawing, the greater the accuracy. By making use of the hundredths scale of the framing square together with a finely pointed pair of dividers, variation in values should not be great.

Solutions of Right Triangles.— By the solution of right triangles is meant the finding of unknown sides or angles when values of other sides and angles are known.

Example 1.—Given $A = 30$ degrees, $c = 24$; Find B, a, b.

Solution—$B = 90 - 30 = 60$ degrees. (The sum of the angles of a triangle equals 180 degrees. $C = 90$ degrees.)

(1) $\frac{a}{c}=\sin A$; whence, $a=c \sin A$. ($a=c$ times sine A.)

(2) $\frac{b}{c}=\cos A$; whence $b=c \cos A$.

From the Tables, Appendix II, sin of A, or 30 degrees, = .5. Substituting numerical values in (1), $a=12$.

Again, from Tables, cos A, or 30 degrees, = .866. Substituting numerical values in (2), $b=20.784$.

Arith. check—$c^2=a^2+b^2$; $24^2=12^2+20.78^2$; $576=144+431.8$; $576=576$.

Graphic check.— The graphic check which, it will be seen, might have been made use of as a graphic solution, consists in setting one square upon another with the angle of direction and the length of one side determined by the data given. That is, in this problem the protractor is set at 30 degrees and a length of 24 units is taken on the inclined square. The lengths of a and b are then carefully measured by taking a reading of the full inches and reading the remaining fraction to hundredths by means of a sharp pair of dividers and the hundredths scale of the square.

Very many carpenters make use of graphic solutions such as this in determining rafter lengths. A little consideration, however, will show that it is a rather risky method of procedure unless the scale is large and the work scaled small. Graphs serve as easy checks against grave errors upon all kinds of work.

Example 2.—Given A and a. To find B, c, and b.

Solution—$B=90$ degrees—A.

$$\frac{a}{c}=\sin A;\ c=\frac{a}{\sin A}$$

$$\frac{b}{c}=\cos A;\ b=c \cos A.$$

Substitute the numerical values and check as in *Example 1*.

Example 3.—Given A and b. To find B, a, and c.

Solution—$B = 90$ degrees—A.

$$\frac{a}{c} = \sin A; \quad a = c \sin A.$$

$$\frac{b}{c} = \cos A; \quad c = \frac{b}{\cos A.}$$

Substitute the numerical values and check as in *Example 1.*

Example 4.—Given a and c. To find A, B, and b.

Solution—$\sin A = \frac{a}{c}$ (That is, look in the tables, Appendix II, for the angle which has a sine equal to the result obtained by dividing the numerical value of the side a by the value of the side c.)

$B = 90$ degrees—A.

$$\frac{b}{c} = \cos A; \quad b = c \cos A.$$

Substitute numerical values and check as in *Example 1.*

Example 5.—Given a and b. To find A, B, and c.

Solution—$\tan A = \frac{a}{b}$

$B = 90$ degrees—A.

$$\frac{a}{c} = \sin A; \quad c = \frac{a}{\sin A.}$$

Substitute numerical values and check as in *Example 1.*

APPENDIX II

Directions.— An examination of the table of natural functions will indicate in the column at the left, angles of 0 degrees to and including 45 degrees, reading down. The column to the extreme right will be found to contain degrees from 45–90 inclusive, reading up.

This compact arrangement of table is made possible thru the fact that sines and cosines, tangents and cotangents are reciprocals one of the other. That is, as the sine (column 2, reading down) increases in value, the cosine of the complementary angle (columns 6 and 2, reading up) decreases.

Example 1.— Find the value of the sine of 40 degrees.

Solution — Columns 1 and 2, reading down, sin 40 degrees = .6428.

Example 2.— Find the value of sin 50 degrees.

Solution — Columns 6 and 5, reading up, sin 50 degrees = .7660.

Example 3.— Find the value of cos 40 degrees.

Solution — Columns 1 and 5, reading down, cos 40 degrees = .7660 (which is as might have been expected. Since 40 degrees is the complement of 50 degrees, the cos 40 degrees should be the same in value as the sin 50 degrees.

Example 4.— Find the value of cos 87 degrees.

Solution — Columns 6 and 2 reading up, cos 87 degrees = .0523

Example 5.— Tangent and cotangent values. Proceed as with sines using columns 1 and 3, reading down, for tangent values between 0–45 degrees inclusive, columns 6 and 4, reading up, for values between 45–90 degrees. For cotangent values between 0–45 degrees use columns 1 and 4 reading down, and columns 6 and 3 reading up for cotangent values between 45–90 degrees inclusive.

TABLE OF NATURAL SINES, TANGENTS, COSINES, AND COTANGENTS

Degrees	Sine	Tangent	Cotangent	Cosine	
0	0	0	∞	1	90
1	.0175	.0175	57.2900	.9998	89
2	.0349	.0349	28.6363	.9994	88
3	.0523	.0524	19.0811	.9986	87
4	.0698	.0699	14.3007	.9976	86
5	.0872	.0875	11.4301	.9962	85
6	.1045	.1051	9.5144	.9945	84
7	.1219	.1228	8.1443	.9925	83
8	.1392	.1405	7.1154	.9903	82
9	.1564	.1584	6.3138	.9877	81
10	.1736	.1763	5.6713	.9848	80
11	.1908	.1944	5.1446	.9816	79
12	.2079	.2126	4.7046	.9781	78
13	.2250	.2309	4.3315	.9744	77
14	.2419	.2493	4.0108	.9703	76
15	.2588	.2679	3.7321	.9659	75
16	.2756	.2867	3.4874	.9613	74
17	.2924	.3057	3.2709	.9563	73
18	.3090	.3249	3.0777	.9511	72
19	.3256	.3443	2.9042	.9455	71
20	.3420	.3640	2.7475	.9397	70
21	.3584	.3839	2.6051	.9336	69
22	.3746	.4040	2.4751	.9272	68
23	.3907	.4245	2.3559	.9205	67
24	.4067	.4452	2.2460	.9135	66
25	.4226	.4663	2.1445	.9063	65
26	.4384	.4877	2.0503	.8988	64
27	.4540	.5095	1.9626	.8910	63
28	.4695	.5317	1.8807	.8829	62
29	.4848	.5543	1.8040	.8746	61
30	.5000	.5774	1.7321	.8660	60
31	.5150	.6009	1.6643	.8572	59
32	.5299	.6249	1.6003	.8480	58
33	.5446	.6494	1.5399	.8387	57
34	.5592	.6745	1.4826	.8290	56
35	.5736	.7002	1.4281	.8192	55
36	.5878	.7265	1.3764	.8090	54
37	.6018	.7536	1.3270	.7986	53
38	.6157	.7813	1.2799	.7880	52
39	.6293	.8098	1.2349	.7771	51
40	.6428	.8391	1.1918	.7660	50
41	.6561	.8693	1.1504	.7547	49
42	.6691	.9004	1.1106	.7431	48
43	.6820	.9325	1.0724	.7314	47
44	.6947	.9657	1.0355	.7193	46
45	.7071	1.0000	1.0000	.7071	45
	Cosine	Cotangent	Tangent	Sine	Degrees

TO FIND THE VALUE OF AN ANGLE, THE VALUE OF A FUNCTION BEING KNOWN

Example 6.— sin = .5150, find the angle.
Solution — Looking in columns 2 and 5 (sine values from 0–90 degrees) Ans. 31 degrees (Columns 2 and 1).

Example 7.— cot = 1.3764, find the angle.
Solution — Looking in columns 3 and 4, Ans. = 36 degrees.

Interpolation.— Frequently one must find a functional value for fractional degrees, or degrees and minutes. Also, it becomes necessary to find the value of an angle with greater accuracy than even degrees, as given in the table herewith. This process of finding more accurate values is known as interpolation.

TO FIND THE VALUE OF A FUNCTION WHEN THE ANGLE IS IN FRACTIONAL DEGREES

Example 8.— Find the value of tan 50 degrees 20 min.
Solution.— tan 50 degrees = 1.1918
tan 51 degrees = 1.2349
difference for an interval of 1 degree = .0431
20 min. $= \frac{20}{60} = \frac{1}{3}$ of 1 degree; $\frac{1}{3}$ of .0431 = .0144
tan 50 degrees 20 min. = 1.1918 + .0144 = 1.2062.

The value of a fractional degree would be similarly treated for the sine, these functions increasing as the value of the angle increases. The cosine and cotangent, however, decrease in value as the angle increases. For this reason the fractional value of the cosine and cotangent must be subtracted from, instead of added to, the value of the function of the next lower number of degrees.

Example 9.— Find the value of cos 26 deg. 30 min.
Solution — cos 26 deg. = .8988
cos 27 deg. = .8910
difference for interval of 1 deg. = .0078
30 min. = $\frac{1}{2}$ of 1 deg.; $\frac{1}{2}$ of .0078 = .0039
cos. 26 deg. 30 min. = .8988—.0039 = .8949.

TO FIND THE VALUE OF AN ANGLE WHEN THE FUNCTIONAL VALUE CANNOT BE FOUND IN EXACT FORM IN THE TABLE

Example 10.— Find the angle whose tan is .5
Solution — From the table, .4877 = tan 26 deg.
.5095 = tan 27 deg.
difference for interval of 1 deg. = .0218
.5000 = tan angle X.
.4877 = tan 26 deg.
difference for interval between tan angle X and tan 26 deg. = .0123
123/218 of 1 deg. or 60 min. = 34 min.
Therefore, angle whose tangent = .5 = 26 deg. 34′.

Rule: (1) Search the body of the table for the functional values next above and next below that given. (2) Find the difference between these functional values. This difference is for an interval of 1 degree or 60 minutes. (3) Find the difference between the given functional value and that of the lower angle of the two used above. (4) Express this last difference as the numerator of a fraction whose denominator is the first difference found, or the difference for the interval of 1 degree. This gives the fractional part of 1 degree or 60 minutes which the second difference is. (5) Express this difference in minutes and add if the function be a sine or tangent, and substract if a cosine or cotangent to the number of degrees representing the angle whose function was the lower of the two functions found given in the table.

APPENDIX III

USEFUL TABLES

FRACTIONAL EQUIVALENTS FOR DECIMAL VALUES

.0156	$\frac{1}{64}$	.2656	$\frac{17}{64}$	.5156	$\frac{33}{64}$	.7656	$\frac{49}{64}$
.0312	$\frac{1}{32}$	.2812	$\frac{9}{32}$	.5312	$\frac{17}{32}$	.7812	$\frac{25}{32}$
.0468	$\frac{3}{64}$	.2968	$\frac{19}{64}$	.5468	$\frac{35}{64}$	.7968	$\frac{51}{64}$
.0625	$\frac{1}{16}$	.3125	$\frac{5}{16}$	.5625	$\frac{9}{16}$	.8125	$\frac{13}{16}$
.0781	$\frac{5}{64}$	.3281	$\frac{21}{64}$	.5781	$\frac{37}{64}$	.8281	$\frac{53}{64}$
.0937	$\frac{3}{32}$	.3437	$\frac{11}{32}$	.5937	$\frac{19}{32}$	.8437	$\frac{27}{32}$
.1093	$\frac{7}{64}$	.3593	$\frac{23}{64}$	.6093	$\frac{39}{64}$	.8593	$\frac{55}{64}$
.125	$\frac{1}{8}$	.375	$\frac{3}{8}$	.625	$\frac{5}{8}$	.875	$\frac{7}{8}$
.1406	$\frac{9}{64}$	.3906	$\frac{25}{64}$	.6406	$\frac{41}{64}$	.8906	$\frac{57}{64}$
.1562	$\frac{5}{32}$	.4062	$\frac{13}{32}$	.6562	$\frac{21}{32}$	.9062	$\frac{29}{32}$
.1718	$\frac{11}{64}$	.4218	$\frac{27}{64}$	.6718	$\frac{43}{64}$	.9218	$\frac{59}{64}$
.1875	$\frac{3}{16}$	.4375	$\frac{7}{16}$	.6875	$\frac{11}{16}$	.9375	$\frac{15}{16}$
.2031	$\frac{13}{64}$	.4531	$\frac{29}{64}$	.7031	$\frac{45}{64}$	.9531	$\frac{61}{64}$
.2187	$\frac{7}{32}$	.4687	$\frac{15}{32}$	.7187	$\frac{23}{32}$	.9687	$\frac{31}{32}$
.2343	$\frac{15}{64}$	.4843	$\frac{31}{64}$	.7343	$\frac{47}{64}$	.9843	$\frac{63}{64}$
.250	$\frac{1}{4}$	.500	$\frac{1}{2}$	.750	$\frac{3}{4}$	1.000	1

Where rafter lengths are determined by multiplying unit lengths by the run, the answer will almost invariably result in a decimal. Such decimal values may be readily translated into fractional forms by means of the accompanying table.

Example: A roof of $\frac{1}{3}$ pitch has a common rafter run of 14′; find the length of common rafter.

Answer: 14x14.42″ = 201.88″ or 16.82′. By the table, .82 = $\frac{53}{64}$. A carpenter, however, would not care for such accuracy; the nearest $\frac{1}{16}$″ or even $\frac{1}{8}$″ would be sufficient.

WOOD AND MACHINE SCREW SIZES

The difference between consecutive sizes is .01316″.

No. of Screw Gage	Size of Number in Decimals	No. of Screw Gage	Size of Number in Decimals	No. of Screw Gage	Size of Number in Decimals
000	.03152	16	.26840	34	.50528
00	.04486	17	.28156	35	.51844
0	.05784	18	.29472	36	.53160
1	.07100	19	.30788	37	.54476
2	.08416	20	.32104	38	.55792
3	.09732	21	.33420	39	.57108
4	.11048	22	.34736	40	.58424
5	.12364	23	.36052	41	.59740
6	.13680	24	.37368	42	.61056
7	.14996	25	.38864	43	.62372
8	.16312	26	.40000	44	.63688
9	.17628	27	.41316	45	.65004
10	.18944	28	.42632	46	.66320
11	.20260	29	.43948	47	.67636
12	.21576	30	.45264	48	.68952
13	.22892	31	.46580	49	.70268
14	.24208	32	.47896	50	.71584
15	.25524	33	.49212		

Frequently the carpenter wishes to know the diameter of hole necessary to receive the shank of a screw of a certain gage. Should a screw gage be accessible, he may readily determine this. Should no gage be at hand, he may determine the size of hole by consulting the accompanying table of Wood and Machine Screw Sizes.

Example: What size bit must be selected to bore a hole for a No. 10 screw. By the table, a No. 10 screw is .18944″ in diameter. By the table of Fractional Equivalents for Decimal Values it will be seen that a $\frac{3}{16}$″ bit must be used. The test for gage of screw is always made over the shank just below the head.

LENGTH AND NUMBER OF WIRE NAILS TO THE POUND

Size	Length ins.	Common	Casing	Finish	Clinch	Fence	Fine	Gal. Shingle
¾	¾	..	...	...	...	...	...	...
⅞	⅞	...	...	...	...	...	...	...
2d	1	900	...	...	...	...	1440	...
3d	1¼	615	...	...	...	...	810	568
4d	1½	322	473	584	...	...	...	250
5d	1¾	254	...	...	...	...	...	...
6d	2	200	180	300	157	114	...	...
7d	2¼	154	...	...	...	...	...	...
8d	2½	106	112	190	99	74	...	...
9d	2¾	85	...	...	...	...	...	...
10d	3	74	90	134	69	42	...	...
12d	3¼	57	...	...	...	...	...	...
16d	3½	46	...	...	...	..	...	...
20d	4	29	...	...	...	...	...	...
30d	4½	23	...	..	..	...	...	...
40d	5	17	...	..	...	...	...	...
50d	5½	14	...	..	...	...	...	...
60d	6	11	...	...	...	...	...	...

Nails are sold in quantity by the keg, 100 lbs. of nails, exclusive of the keg. Twenty, 30, 40, 50 and 60d are "base." Other sizes have certain fixed additions per keg to this base price. For example, the price list adopted by manufacturers in 1896 allows an addition per keg of $.70 for 2d common, $.45 for 3d common, etc.

Wire nails are also bought and sold by weight, the size of wire according to the standard wire gage and the length in inches being taken into consideration in specifying the size and in fixing the price per pound.

Common wire nails are thick and have large flat heads. They are used in rough work where strength is desired. Finishing nails are used for fine work such as inside woodwork and cabinet work. Casing nails are somewhat thicker and stronger than finishing nails; they have smaller heads.

WIRE BRADS

Size, inches	½	½	⅝	¾	¾	¾	⅞	⅞	1
Wire Gage, nos.	20	18	19	19	18	16	18	17	18
Approx. no. brads to lb.	7500	7200	4267	3556	2758	2600	2364	1781	2069
Size, inches	1	1	1¼	1¼	1½	1½	1½	1¾	1¾
Wire Gage, nos.	17	16	17	16	16	15	14	15	14
Approx. no. brads to lb.	1558	1143	1246	913	761	584	500	500	406
Size, inches	2	2	2½	2½	3	3	3	...	...
Wire Gage, nos.	14	13	13	12	14	12	11	..	..
Approx. no. brads to lb.	350	268	214	164	150	137	105	...	...

BOARD MEASURE TABLE

Size in Inches	Length, in feet, of Joist, Scantling and Timber														
	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
2x 4	8	9	11	12	13	15	16	17	19	20	21	23	24	25	27
2x 6	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
2x 8	16	19	21	24	27	29	32	35	37	40	43	45	48	51	53
2x10	20	23	27	30	33	37	40	43	47	50	53	57	60	63	67
2x12	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80
2x14	28	33	37	42	47	51	56	61	65	70	75	79	84	89	93
3x 6	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60
3x 8	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80
3x10	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
3x12	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120
3x14	42	49	56	63	70	77	84	91	98	105	112	119	126	133	140
4x 4	16	19	21	24	27	29	32	35	37	40	43	45	48	51	53
4x 6	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80
6x 6	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120
6x 8	48	56	64	72	80	88	96	104	112	120	128	136	144	152	160
8x 8	64	75	85	96	107	117	128	139	149	160	171	181	192	203	213
8x10	80	93	107	120	133	147	160	173	187	200	213	227	240	253	267
10x10	100	117	133	150	167	183	200	217	233	250	267	283	300	317	333
10x12	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400
12x12	144	168	192	216	240	264	288	312	336	360	384	408	432	456	480
12x14	163	196	224	252	280	308	336	364	392	420	448	476	504	532	560
14x14	196	229	261	294	327	359	392	425	457	490	523	555	588	621	653

STRENGTH OF MATERIALS

YELLOW PINE POSTS

Load in Tons

Length in ft.	Size in inches					
	4x4	5x5	6x6	7x7	8x8	9x9
8	4	5	6	7	8	9
10	3	4	5	6	7	8
12	2	3	4	5	6	7
14	1	2	3	4	5	6
16	...	1	2	3	4	5
18	...	...	1	2	3	4

HARD PINE BEAMS AND GIRDERS

Load in Tons

Length in ft.	Size in inches				
	2x6	3x6	4x6	6x6	8x8
6	1	1½	2	3	5½
8	¾	1	1½	2½	5
10	...	¾	1¼	2	4½
12	...	½	1	1½	3
14	...	...	½	1	2½
16	...	...	...	½	2
18	...	...	...	...	1

STEEL I BEAMS

Load in Tons

Length in ft.	Size in inches		
	6	8	12
10	7	14	18
12	6	12	16
14	5	10	14
16	4	8	12
18	2	6	10
20	..	4	8
22	..	2	6
24	..	..	4

BRICK PIERS

Load in Tons

Height in ft.	Size in inches						
	6x6	6x8	8x8	8x12	12x12	12x16	16x16
6	2	3	4	5	6	7	9
8	1½	2½	3½	4½	5½	6	8
10	1	2	3	5	5½	6	7

STRESSES FOR STRUCTURAL TIMBERS

WORKING UNIT STRESSES USED IN DRY LOCATIONS

Species of Timber	Bending		Compression	
	Stress in extreme fibre Lbs. sq. in.	Horizontal shear stress Lbs. sq. in.	Parallel to grain "Short Columns" Lbs. sq. in.	Perpendicular to grain Lbs. sq. in.
*Fir, Douglas—				
Dense grade	1,600	100	1,200	350
Sound grade	1,300	85	900	300
Hemlock, eastern	1,000	70	700	300
Hemlock, western	1,300	75	900	300
Oak	1,400	125	900	400
Pine, eastern white	900	80	700	250
Pine, Norway	1,100	85	800	300
*Pine, southern yellow—				
Dense grade	1,600	125	1,200	350
Sound grade	1,300	85	900	300
Spruce	900	70	600	200
Tamarack	1,200	95	900	350

* Note: The safe working stresses given in this table are for timbers with defects limited according to the sections on defects in the rules of the Southern Pine Association for Select Structural Material. "Dense" southern yellow pine and "dense" Douglas fir should also conform to the other requirements of this rule. "Sound" southern yellow pine and "sound" Douglas fir require no additional qualifications, whereas the other species should, in addition to being graded for defects, have all pieces of exceptionally low density for the species excluded.

This table gives working unit stresses for structural timbers used in dry locations, and is compiled in the main from material furnished by the Forest Products Laboratory, Madison, Wis.

TABLE OF BRICK WALL CONTENTS IN NUMBER OF BRICKS

Seven Bricks to Each Sq. Ft. of Wall Surface

No. of sq. ft. of wall	Thickness					
	4″	8″	12″	16″	20″	24″
1	7	15	23	30	38	45
2	15	30	45	60	75	90
3	23	45	68	90	113	135
4	30	60	90	120	150	180
5	38	75	113	150	188	225
6	45	90	135	180	225	270
7	53	105	158	210	263	315
8	60	120	180	240	300	360
9	68	135	203	270	338	405
10	75	150	225	300	375	450
20	150	300	450	600	750	900
30	225	450	675	900	1,125	1,350
40	300	600	900	1,200	1,500	1,800
50	375	750	1,125	1,500	1,875	2,250
60	450	900	1,350	1,800	2,250	2,700
70	525	1,050	1,575	2,100	2,625	3,150
80	600	1,200	1,800	2,400	3,000	3,600
90	675	1,350	2,025	2,700	3,375	4,050
100	750	1,500	2,250	3,000	3,750	4,500

Example — Determine the number of bricks in a wall 12″×18′×60′.

Solution — The wall contains a surface area of 1,080 sq. ft. By the table 100 sq. ft. contains 2,250 bricks, then 1,000 sq. ft. will contain 22,500 bricks. 80 sq. ft. will contain, by the table, 1,800 bricks, making a total of 24,300 bricks.

APPENDIX IV

(Short Cuts to Roof Framing)

Griffith's Framing Tables for the Square and Octagonal Roof

Directions for Using Table for the Steel Square.— Fig. 70-a.

Example.— Given a square hipped roof, that is, a roof with square corners, having a span of 25 ft. and a pitch of ½.

1. *To Lay Out Miter Cut of Plate.*— Take 12″ on tongue of framing square and 12″ on blade; scribe along blade. (Cf. small table, Fig. 70-a.)

2. *Length of Ridge.*— Length of long plate diminished by length of short plate, increased by thickness of ridge piece plus diagonal thickness of hip.

3. *To Lay Out Common Rafter.*—
   a. Plumb cut.— (Cf. column 5, beginning at left, Fig. 70-a.) Take 12″ on tongue of square and 12″ on blade (column 2), scribe along blade.
   b. Length of common rafter.— (Cf. column 11) 12½ (run of common rafter) x 16.97″ (length of common rafter per foot of run) = 17′ 8.12″ = 17′ 8⅛″ (.12″ = ⅛″, columns 3 and 4).
   c. Seat cut.— (Cf. column 8) Take 12″ on tongue and 12″ on blade; scribe along tongue.
   d. Tail for common rafter.
      (1) Length — determined as was that of common rafter, the horizontal projection or length of lookout becoming multiplier.

(2) End cut — use same numbers as for plumb cut but invert position of square.

e. Reduction for ridge.— Measure straight back from plumb cut a distance equal to ½ the thickness of ridge piece.

4. *To Lay Out Hip or Valley Rafter.*—

a. Plumb cut.— (Cf. column 6) Take 17″ on the tongue and 12″ on the blade; scribe along the blade.

b. Side cut.— (Cf. column 16) Take 17″ on the tongue and 20.78″ or $20\frac{13}{16}$″ (columns 3 and 4) on the blade; scribe along the blade.

This also gives the miter cut at the end of the tail of the hip for fascia, and also the miter cut at the bird's mouth joint of valley rafter, where it must be cut out to fit the angle of the plate.

c. Length of hip or valley rafter.— (Cf. column 12) 12½ (run of common rafter) x 20.78″ (length of hip or valley rafter per foot of run of common rafter) = 21′ 7.75″ = 21′ 7¾″ (.75 = ¾, columns 3 and 4.)

d. Seat cut.— (Cf. column 9) Take 17″ on tongue and 12″ on the blade, scribe along the tongue.

e. Tail for hip or valley rafter.—

(1) Length — determined as was that of hip or valley rafter, the horizontal projection of tail or length of the lookout of common rafter becoming the multiplier.

(2) End cut — use same numbers as for plumb cut of hip or valley but invert square.

f. Reduction for ridge.— Measure straight back from plumb cut ½ diagonal thickness of ridge.

g. Backing of hip.— (Cf. column 21) Take 12″ (rise of common rafter) on the tongue and $20\frac{13}{16}$″ on the blade, scribe along the tongue for angle of backing.

h. Drop of hip when no backing is given.— (Cf. column 23) Reduce at seat cut $\frac{9}{16}$″, measured at right angles to seat cut.

5. *To Lay Out Jacks.*—

a. Plumb cut.— Same as that for the common rafter.

b. Side cut.— (Cf. column 14) Take 12″ on the tongue and 16.97″ or 17″ on blade (.97″=1″, columns 3 and 4), scribe on the blade.

Scribing along the tongue will give the face cut of roof boards, also of plancher.

c. Length.— Jacks set 24″ centers, beginning with shortest jack=2′ 10″ (column 19). Second shortest jack=length of shortest increased 2′ 10″, etc.

Beginning with longest jack=length of common rafter diminished by 2′ 10″, etc.

d. Tail for jack.— Same as for common rafter.

6. *Note.*—

All rafter lengths are measured down the middle of the top edges theoretically. On the square cornered roof, measurements of hip or valley rafters may be made from the long point without further reduction in length providing a 2″ thick ridge is used. Jacks need no further reduction in length on a square cornered building provided the hips or valleys are of the same thickness as the jacks and the measurements are made from the long points of the jacks. Otherwise suitable reductions must be made for rafter and ridge thicknesses.

Directions for Using Table for Protractor.— Fig. 70-b.

EXAMPLE.— Given to frame an octagonal silo with a span of 21′ and a roof pitch of 11″ to the foot.

1. *To Lay Out Miter Cut of Plate.*— (Cf. small table Fig. 70-b.) Eight sided polygon, plate miter = 67½ degrees. Set a T-bevel by means of a protractor* to this angle.

2. *To Find Length of a Side for Plate.*— (Cf. small table, Fig. 70-b.) 21′ (2 x run) x .414 (cotangent of octagon) = 8.69′ = 8¾′ (.69 = ¾, columns 3 and 4.)

3. *To Lay Out Common Rafter.*—
   a. Plumb cut.— (Cf. column 5) = 47 deg. 30 min. Set T-bevel by means of protractor to same.
   b. Length — (Cf. column 11). Take 10½ (run) x 16.28″ (length of common rafter per foot of run) = 14′ 2.94″ = 15′. (.94 = 1, columns 3 and 4.)
   c. Seat cut.— (Cf. column 8) 42 deg. 30 min. Set T-bevel by means of protractor.
   d. Tail.—
      (1) Length — Determined as is length of common rafter (Cf. column 11), horizontal projection of tail or length of lookout becoming the multiplier.
      (2) End cut.— Use same number of degrees as for plumb cut.

4. *To Lay Out Hip or Valley Rafter.*—
   a. Plumb cut.— (Cf. column 7) = 49 deg. 50 min.
   b. Side cut.— (Cf. column 17) = 17 deg. 40 min. This also gives miter cut at end of hip tail for fascia, and also the miter cut of the bird's mouth joint of valley rafter, where it must be cut out to fit the angle of the plate.

*Starrett's "Framing Tool" is strongly recommended for framing in degrees, Cf. Figs. 81 and 82.

c. Length of hip or valley rafter.— (Cf. column 13) $10\frac{1}{2}$ (run of common rafter) x 17.03″ (length of octagon hip or valley per foot of run of common rafter) = 14′ 10.32″ = 14′ $10\frac{3}{8}$″ (.32 = $\frac{3}{8}$, columns 3 and 4).

d. Seat cut.— (Cf. column 10) = 40 deg. 10 min. Use protractor and T-bevel.

e. Tail for hip or valley rafter.—

(1) Length.— Determined as for hip or valley, horizontal projection of tail or length of lookout of common rafter becoming multiplier.

(2) End cut.— Use same number of degrees as for plumb cut of hip or valley.

f. Backing of hip.— (Cf. column 22) = 74 deg. 50 min.

g. Drop of hip when no backing is used. (Cf. column 24) = $\frac{5}{16}$″.

5. *To Lay Out Jacks.*—

a. Plumb cut.— Same as for common rafter.

b. Side cut.— (Cf. column 15) = 17 deg.

c. Length.— (Cf. column 20) = $\frac{1}{5}^2$ that for square roof of same pitch. When set 16″ centers = $\frac{1}{5}^2$ x $21\frac{3}{4}$″ = $52\frac{1}{1}\frac{1}{2}$″, common difference. Proceed accordingly.

d. Tail for jack.— Same as for common rafter.

APPENDIX V

Miscellaneous Estimating

Excavations.— Excavations are estimated in terms of the cubic yard, 27 cubic feet. The price per yard will vary according to the nature of the soil.

Where ground is not level, the plot should be divided into squares, each square being figured as to its cubical contents and the various amounts combined.

ANALYSIS OF COST FACTORS PER CUBIC YARD

Spading or picking—labor, ¾ hour at.....
Throwing out—labor, ¾ hour at.....
Wheeling 50 feet, ⅜ hour at.....

Cost per yard .....$

Concrete.— Concrete is estimated in terms of the cubic yard. The price will vary somewhat according to the mixture and the amount of form work required. Mixtures are designated as "rich" — 1 part cement, 2 parts sand, 4 parts crushed rock, by volume; "medium" — 1:2½:5; "ordinary" 1:3:6, and "lean," 1:4:8. The rich mixture is used for cellar floors on high grade work. Cisterns and tanks make use of a special mixture of 1:2:3, the stone or gravel being passed thru a ¼" screen. Cement topping for cellar floors is a mortar composed of 1 part cement and 2 parts sharp sand. Sometimes a 1:1 mixture is used. Cellar floors and sidewalks are often priced by the foot surface measure, standard specifications for depth and construction being understood.

TABLE FOR ESTIMATING QUANTITIES FOR CONCRETE

(Proportion of materials in one cubic foot of concrete.)

	MIXTURE		
	Rich (1:2:4)	Medium (1:2½:5)	Ordinary (1:3:6)
Cement	0.058 bbl.	0.048 bbl.	0.041 bbl.
Sand	0.0163 cu. yd.	0.0170 cu. yd.	0.0174 cu. yd.
Stone or gravel	0.0326 cu. yd.	0.0341 cu. yd.	0.0348 cu. yd.

Example — Estimate quantities of various materials needed for a wall 10″×7′×48′, using a 1:2½:5 mixture.

Solution — $\frac{10\times7\times48}{12}=280$ cu. ft.

Cement = 280×0.048 bbl. = 13.44 bbl.
Sand = 280×0.017 cu. yd. = 4.76 cu. yd.
Stone = 280×0.0341 cu. yd. = 9.548 cu. yd.

Knowing the cost of cement per bbl. and of sand and stone per cu. yd., the cost of materials for the wall may be easily determined.

TABLE FOR ESTIMATING QUANTITIES FOR CEMENT MORTAR

(Proportion of materials in one cubic foot of cement mortar)

	MIXTURE		
	1:1½	1:2	1:2½
Cement	0.1481 bbl.	0.1239 bbl.	0.1052 bbl.
Sand	0.0311 cu. yd.	0.0344 cu. yd.	0.0370 cu. yd.

Example — Estimate quantities of material for 1:2 cement mortar for topping of cellar floor 1″×24′×40′.

Solution — $\frac{24\times40}{12}=80$ cu. ft.

Cement = 80×0.1239 bbl. = 9.912 bbl.
Sand = 80×0.0344 cu. yd. = 2.752 cu. yd.

ANALYSIS OF LABOR COST FACTORS PER CUBIC YARD

1 mason, 2 hours @ .....
2 laborers, 2 hours each @ .....

Total .....$
Where forms are required add: .....
1 carpenter, 2½ hours @ .....

Cellar floor construction costs approximately the same as wall work having forms. The expense of form work in ordinary base-

ment wall construction is offset by labor and additional cement cost of topping of cellar floor.

Brickwork.— The unit of measurement in brickwork is the 1000 bricks, ordinarily.

To determine the number of bricks in a wall, multiply each square foot of surface by 7 (sometimes 7½ is used) which is the average number of bricks per foot of wall when 4″ thick. Add 5% for breakage. Deduct for openings over 2′ square. For walls thicker than 4″, make suitable allowance.

A mason can lay 800 to 1000 common and 300 to 400 face bricks in a day.

Bricks may be laid in lime mortar or in cement mortar.

ANALYSIS OF COST FACTORS PER 1000 BRICKS, LIME MORTAR 1:3

Brick, 1000 @ .....
Lime, 3 bu. @ .....
Sand, ½ cu. yd. @ .....
Mason, 10 hrs. @ .....
Tender, 10 hrs. @ .....

Total .....$

ANALYSIS OF COST FACTORS PER 1000 BRICKS, CEMENT MORTAR 1:3

Brick, 1000 @ .....
Portland cement, 1¼ bbl. @ .....
Sand ½ cu. yd. @ .....
Mason, 10 hrs. @ .....
Tender, 10 hrs. @ .....

Total .....$

Chimneys.— One foot of chimney height will contain five courses of ordinary bricks.

CHIMNEYS

No. Flues	Size of Flue	Size of Chimney	No. Bricks per Ft.
1	8″× 8″	16″×16″	30
2	8″× 8″	16″×28″	50
3	8″× 8″	16″×40″	70
1	12″×12″	20″×20″	40

Slate Roof.— Exposure of each slate will equal the length of a slate diminished by 3″ (the usual amount of lap) divided by 2, multiplied by the width of the slate.

To determine the number of slates required, divide the area to be covered by the exposure of each slate as determined just above.

Example — Determine the number of 6″×12″ slates required to cover a surface 16′×20′.

Solution — $\frac{12''-3''}{2}\times 6''=27$ sq. in.

$$\frac{16\times 20\times 144''}{27''}=1707 \text{ slates.}$$

TABLE OF SLATES PER SQUARE OF 100 FEET

Size	Length of Expos.	No. Req.	Nails Req.
6″×12″	4½″	533	3.8 lbs.
7″×14″	5½″	377	2.66
8″×16″	6½″	277	2
9″×18″	7½″	214	1.5

ANALYSIS OF COST FACTORS PER SQUARE. (100 SQ. FT.)

Slate, @ .....
Slater, 8 hrs., @ .....
Roofing Paper, @ .....
Placing paper, 20 min. .....
Nails, 2 lbs. (8″x16″ slate) @ .....

Total .....$
Metal work extra.

Plastering.— Plastering is estimated by the square yard. In estimating the number of square yards, deduct ½ the area of openings. The extra labor involved in working around grounds is thus allowed for. Strips of plastering less than 1 foot wide are estimated as a foot in width. Closet areas are increased by ½ to make allowance for the extra labor involved in working small surfaces. Special plastering of cornice, etc., will be charged extra.

Lathing is usually a part of the plasterer's contract, tho done by a different set of workmen. The unit is either the square yard or the 1000 laths.

ANALYSIS OF COST FACTORS FOR LATHING A SQUARE (100 SQ. FT.)

Lath, 1500 @ .....
Nails, 10 lbs. 3d fine @ .....
Lather, 8 hrs. @ .....

Total ..... $

ANALYSIS OF COST FACTORS PER SQUARE FOR 2-COAT LIME PLASTER

Lime, 10 bu. @ .....
Hair, 6 lbs. @ .....
Sand, 1 yd. @ .....
2 plasterers, 12 hrs. each @ .....
1 helper, 12 hrs. @ .....

Total ..... $

ANALYSIS OF COST FACTORS PER SQUARE FOR 3-COAT LIME PLASTER

Lime, 13 bu. @ .....
Hair, 8 lbs. @ .....
Sand, 1½ yds. @ .....
Plaster of Paris, 1 bbl. @ .....
2 plasterers, 16 hrs. each @ .....
1 helper, 16 hrs. .....

Total ..... $

Painting.— Painting is estimated by the square yard, no deductions being made for openings such as doors and windows. Railings, grills, etc., are figured as if solid.

A gallon of paint will cover approximately 250 to 300 sq. ft. of old work and 350 ft. of new work. A painter should cover 150 sq. ft., 1st. coat, per hour, and 90 sq. ft., 2nd coat.

Cost factors may be easily determined from the above statements, and costs easily estimated for ordinary work.

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INDEX

(NUMBERS REFER TO PAGES)

A

American Bond 20
Anchor, Brick Wall 139
Angle Post 118
Apron 109
Architrave 109
Ashlar 20

B

Backing Hip Rafter for Square Cornered Building 63
Octagon and Other Hips 80
Balloon Frame 27
Base Block 109
Blocks, Placing 128
Mould 109
Mould, Placing 129
Batter Boards 15
Bed Moulding 98
Belt Course 110
Bibliography of Reading References 183
Blind Stop 109, 138
Board Measure Table 169
Bonds, Masonry 20
Brick Walls 20
Contents Table 172
Bridging 32
Building Paper 95, 98

C

Casing 109, 138
Casings, Placing 128
Chalk Line 103
Common Rafter 74
Concrete Mixtures 19
Corner Boards 109
Board, Splicing 102
Posts 38, 39, 109
Cornice 98
Costs, by Percentages 156
Example of Form 154
Counter Flashing 107
Cove 118
Crown Moulding 98

D

Deck 94
Door, Fitting 130
Frame 137
Hanging 129
Hinging 131
Jambs, Setting 125
Parts Named 129
Sill 109
Trim, Placing 127
Drain Tile 24
Drip Cap 109, 138
"Duck" 127

E

End Cut of Common Rafter 55
of Hip and Valley Rafter 62
of Octagonal and Other Hips and Valleys 79
English Bond 20
Estimating 142
Brick Work 180

Estimating Cement Mortar..... 179
Concrete..... 178
Cubic-foot Unit 142
Excavations..... 178
Labor Costs, Carpentry..... 150
Lathing..... 182
Lumber Quantities..... 146
Millwork Quantities..... 149
Painting..... 182
Plastering.....181, 182
Quantities of Nails..... 153
Slate Roof..... 181
Excavations..... 18
Exterior Wall Coverings..... 95

F

Fascia..... 98
Finish Floor..... 109
Finishing Exterior Walls..... 108
Flashing..... 105
Flemish Bond..... 20
Floors, Laying and Scraping.... 135
Footings..... 18
Forms for Concrete..... 23
Foundations..... 18
Laying out..... 13
Foundation Materials..... 19
Frames, Basement..... 25
Framing Common Rafter..... 49
Joists..... 31
Roof about Chimney..... 94
Square with Rafter Table..... 53
Table for Common and Jack Rafters..... 52
Frieze..... 98
Full Frame..... 27
Furring..... 109

G

Girders.....29, 31
Grade Line..... 16
Grading Rules, Lumber..... 143
Griffith's Roof Framing Tables... 72
Griffith's Tables, Directions for.. 173
Grounds..... 115

H

Half-frame..... 27
Headers.....20, 35, 109
Headroom..... 119
Hip and Valley Rafter End Cut. 62
and Valley Rafter Lengths.... 61
and Valley Rafter Plumb Cut. 60
and Valley Rafter Seat Cut... 62
and Valley Rafters for Octagon and other Polygons..... 74
and Valley Rafter Side Cut... 60
Rafter, Unit Lengths..... 59

I

Interior Finish.....115, 125
Walls..... 117
Interpolation..... 164

J

Jamb.....109, 138
Jack Rafter for Octagonal and Other Polygonal Roofs..... 81
for Square Cornered Building. 65

K

King-Post..... 78

L

Lap Siding..... 111
Lathing..... 115
Length and Number of Wire Nails to the Pound..... 168
Length of Common Rafter.....50, 54
of Hip and Valley Rafters.... 61
of Jacks for Square Cornered Building..... 66

INDEX

(NUMBERS REFER TO PAGES)

A

American Bond..... 20
Anchor, Brick Wall..... 139
Angle Post..... 118
Apron..... 109
Architrave..... 109
Ashlar..... 20

B

Backing Hip Rafter for Square Cornered Building..... 63
Octagon and Other Hips..... 80
Balloon Frame..... 27
Base Block..... 109
Blocks, Placing..... 128
Mould..... 109
Mould, Placing..... 129
Batter Boards..... 15
Bed Moulding..... 98
Belt Course..... 110
Bibliography of Reading References..... 183
Blind Stop.....109, 138
Board Measure Table..... 169
Bonds, Masonry..... 20
Brick Walls..... 20
Contents Table..... 172
Bridging..... 32
Building Paper.....95, 98

C

Casing.....109, 138
Casings, Placing..... 128
Chalk Line..... 103
Common Rafter..... 74
Concrete Mixtures..... 19
Corner Boards..... 109
Board, Splicing..... 102
Posts.....38, 39, 109
Cornice..... 98
Costs, by Percentages..... 156
Example of Form..... 154
Counter Flashing..... 107
Cove..... 118
Crown Moulding..... 98

D

Deck..... 94
Door, Fitting..... 130
Frame..... 137
Hanging..... 129
Hinging..... 131
Jambs, Setting..... 125
Parts Named..... 129
Sill..... 109
Trim, Placing..... 127
Drain Tile..... 24
Drip Cap.....109, 138
"Duck"..... 127

E

End Cut of Common Rafter..... 55
of Hip and Valley Rafter..... 62
of Octagonal and Other Hips and Valleys..... 79
English Bond..... 20
Estimating..... 142
Brick Work..... 180

Estimating Cement Mortar..... 179
Concrete..... 178
Cubic-foot Unit 142
Excavations..... 178
Labor Costs, Carpentry..... 150
Lathing..... 182
Lumber Quantities..... 146
Millwork Quantities..... 149
Painting..... 182
Plastering.....181, 182
Quantities of Nails..... 153
Slate Roof..... 181
Excavations..... 18
Exterior Wall Coverings..... 95

F

Fascia..... 98
Finish Floor..... 109
Finishing Exterior Walls..... 108
Flashing..... 105
Flemish Bond..... 20
Floors, Laying and Scraping.... 135
Footings..... 18
Forms for Concrete..... 23
Foundations..... 18
Laying out..... 13
Foundation Materials..... 19
Frames, Basement..... 25
Framing Common Rafter..... 49
Joists..... 31
Roof about Chimney..... 94
Square with Rafter Table..... 53
Table for Common and Jack Rafters..... 52
Frieze..... 98
Full Frame..... 27
Furring..... 109

G

Girders.....29, 31
Grade Line..... 16
Grading Rules, Lumber..... 143
Griffith's Roof Framing Tables... 72
Griffith's Tables, Directions for.. 173
Grounds..... 115

H

Half-frame..... 27
Headers.....20, 35, 109
Headroom..... 119
Hip and Valley Rafter End Cut. 62
and Valley Rafter Lengths.... 61
and Valley Rafter Plumb Cut. 60
and Valley Rafter Seat Cut... 62
and Valley Rafters for Octagon and other Polygons..... 74
and Valley Rafter Side Cut... 60
Rafter, Unit Lengths..... 59

I

Interior Finish.....115, 125
Walls..... 117
Interpolation..... 164

J

Jamb.....109, 138
Jack Rafter for Octagonal and Other Polygonal Roofs..... 81
for Square Cornered Building. 65

K

King-Post..... 78

L

Lap Siding..... 111
Lathing..... 115
Length and Number of Wire Nails to the Pound..... 168
Length of Common Rafter.....50, 54
of Hip and Valley Rafters.... 61
of Jacks for Square Cornered Building..... 66

Length of Octagon and Other Polygonal Jacks..... 82
of Rafter by Scaling..... 53
of Side of Polygon..... 73
Leveling Door Sill..... 110
Foundation..... 16
Rod..... 14
with Straight-edge..... 17
Lintels..... 141
Locks, Fitting..... 132
Lookout..... 98
Lookouts, Framing..... 99

M

Main Frame..... 27
Masonry Construction, Woodwork for..... 138
Miter Cuts of Plate..... 69

N

Natural Trigonometric Functions 158
Nosing..... 118

O

Octagonal and Other Jacks..... 81
Roofs..... 73
Octagon Bay, Framing..... 85
Openings in Framework.....42, 94

P

Parting Strip.....109, 138
Partition..... 38
Wall Detail..... 116
Patterns for Joists and Studding. 38
Pier..... 123
Pitch..... 46
Pitch Board..... 120
Placing Joists.....32, 41
Plancher..... 98
Plank Frame..... 27
Plates.....41, 98
Platform, Stair..... 118
Plumb Cut of Hip and Valley Rafter..... 60
of Octagonal Hip and Valley Rafters..... 74
Porches..... 122
Porch Steps..... 117
Protractor, Framing with..... 82
Pulleys..... 138
Pulley Stile.....109, 138

R

Raked Moulding..... 100
Reduction for King-post..... 79
for Ridge..... 57
Ribbon Boards..... 39
Ridge, Length of..... 56
Piece..... 57
Rise..... 46
Rise of Stair..... 119
Riser.....118, 121
Roof Boards, Cutting of.....95, 96, 98
Frame..... 45
Frame, Any Polygon..... 69
Framing..... 45
Framing Terms..... 46
Rough Floors.....42, 109
Rubble Work..... 20
Run..... 45
Run of Stair..... 119

S

Sash Cord..... 127
Scaffolding..... 96
Scribing Against Irregular Surface 114
Seat Cut of Common Rafter.... 55
of Hip and Valley Rafter..... 62
of Octagonal and Other Hips and Valleys..... 79
Setting Basement Frames..... 25

Setting Partitions 41
Studs 40
Window Frames..... 110
Sheathing or Sheeting.....95, 98
Shed Roof Framing..... 89
Shingling..... 102
Hips and Valleys..... 105
Shingle Tins..... 106
Shoe Mould..... 109
Placing..... 129
Side Cut, Hip and Valley Rafters 60
Octagonal and Other Hips and Valleys..... 75
of Jack Rafter..... 65
of Octagonal and Other Polygonal Jacks..... 81
Siding..... 111
Circular Tower..... 113
Hook..... 113
Stick..... 111
Sills.....29, 31, 109, 138
Six-eight-ten Method 15
Sole Piece..... 109
Solution of Right Triangles..... 159
Spacing Joists..... 32
Stair Building..... 117
Types..... 118
Stirrups..... 36
Stock Bill Form..... 149
Stone Work..... 20
Stool..... 109
Stop Bead.....109, 138
Story Pole..... 42
Straightening Studding..... 117
Strength of Materials..... 170
Stretchers..... 20
Stringer..... 118

T

Table for Hip and Valley Rafters. 60
of Common and Jack Rafters. 52
Table of Fractional Equivalents for Decimal Values..... 166
of Natural Functions..... 163
of Octagonal Hip and Valley Rafters..... 75
Tail, Rafter..... 56
Tangents..... 69
Threshold..... 109
Toe Hold..... 104
Transit..... 13
Translating Framing Problems from Protractor to Framing Square and Vice Versa..... 84
Tread.....118, 121
Trimmers..... 35

U

Uneven Pitch of Roof..... 90
Useful Tables..... 166

V

Valley Rafters..... 65
Rafter Unit Lengths..... 58
Value of a Function, The Angle Being Given in Fractional Degrees..... 164
of Angle, The Value of a Function Being Known..... 164
Veneer, Brick..... 138

W

Wall Board..... 121
Walls..... 38
Water Proofing..... 24
Table..... 109
Weight Pocket.....109, 138
Well Hole..... 36
Winders, Stair..... 118
Window Detail, for Brick Wall.. 140
Frames..... 137
Sash, Fitting..... 126

Window Sill..... 109
Stool..... 109
Trim, Placing..... 127
Wire Brads, Table for..... 169
Wood and Machine Screw, Sizes Table of..... 167
Wooden Bricks..... 26
Wood's Key to the Steel Square. 70

Y

Y-level..... 14
Yoke..... 109